



Wells G & H
Site
Woburn, MA

Draft
**REMEDIAL DESIGN
INVESTIGATION REPORT
AND FINAL DESIGN**

**Northeast Quadrant of
the Wells G & H Site
Woburn, Massachusetts**

**Volume I
Remedial Design Investigation Report**

PREPARED FOR

UniFirst Corporation

and

W.R. Grace & Co. - Conn.

SUBMITTED TO

U.S. Environmental Protection Agency
Region I

October 22, 1991

Environmental Project Control, Inc.
Two Grafton Common
Post Office Box 536
Grafton, Massachusetts 01519

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EXECUTIVE SUMMARY

Introduction

This report is submitted by UniFirst Corporation ("UniFirst") and W.R. Grace - Conn. ("Grace") pursuant to an administrative order by consent, EPA Docket No. CERCLA 1-90-1035 (the "AOC"). The AOC required UniFirst and Grace to carry out design investigations at and in the vicinity of their respective properties located within the Wells G & H Superfund Site in Woburn, Massachusetts (the "Site"), and to prepare a final design for the remediation of ground-water contamination at and in the vicinity of their properties. The remedial objectives for ground water set forth in the AOC were: (1) to prevent further migration of contaminated ground water from the Source Areas to the Central Area of the Wells G & H Site; (2) to restore the ground water in the vicinity of the Source Areas to specified levels; and (3) to prevent public contact with contaminated ground water above the specified cleanup levels.

Description of Predesign Investigations

The design investigations the AOC required UniFirst and Grace to carry out consisted of two principal elements. The first element was the performance of pumping tests utilizing ground-water recovery wells located on the UniFirst and the Grace properties in order to determine those wells' hydraulic capture zones. The second element was the testing of technologies for treatment of contaminated ground water recovered by those wells. For the pumping test, bedrock well UC22 on the UniFirst property was pumped for 30 days at 50 gallons per minute commencing on May 1, 1991. This exactly matched the planned rate and duration. On the Grace property, a pumping test was carried out on ten recovery wells during the ten day period beginning on May 10, 1991. These wells were pumped at an average total rate of approximately six gallons per minute. Once again, this duration and rate were as planned.

During these pumping tests, pilot treatment systems were evaluated by treatment of the ground water recovered during the pumping test. The overall goals of the treatability tests were: (1) to obtain treatability data and design information for the proposed treatment processes; (2) to better characterize the influent quality for the purposes of design; and (3) to ensure that discharge limits were not exceeded during the period of pumping.

Previous analyses of ground water indicated that the primary contaminants on the UniFirst and Grace properties were chlorinated volatile organic compounds (VOC). The proposed treatment systems for the UniFirst and Grace properties involved filtration of ground water followed by

oxidation of VOC by ultraviolet ("UV") radiation and hydrogen peroxide. In the UniFirst system, the UV/peroxide treatment was followed by treatment with granular activated carbon ("GAC"). The UniFirst pilot treatment system also evaluated two innovative technologies. One was an experimental reductive dehalogenation unit based on methodology currently being developed by the University of Waterloo and consist of two canisters filled with a mixture of sand, iron filings, and GAC. The second was an automated VOC analytical system designed to provide automatic sampling and high-quality analyses in a highly cost-effective manner.

Results

The pumping and treatability tests were unqualified successes. They not only achieved the remedial design objectives, they exceeded them. The deep bedrock capture zone for the UniFirst recovery system is very large, extending off the UniFirst property in all directions, and approximately 1500 feet south of the UniFirst property. In addition to the extremely large horizontal extent of the capture zone, the vertical extent of the capture zone is also quite deep, exceeding 390 feet at one well located approximately 500 feet south of the UniFirst property.

The Grace recovery system was intended to capture contaminated ground water in the unconsolidated deposits and shallow bedrock at the Grace property, allowing any contaminants in the deeper bedrock to flow into the capture zone of the UniFirst recovery system. The estimated capture zones for the Grace recovery system in the unconsolidated deposits and the shallow bedrock extended over the majority of the Grace property, and was still expanding at the end of the pumping test.

As with the recovery systems, the treatment systems' performance exceeded the stated design criteria and the remedial design objectives. Contaminated ground water treated with the UniFirst UV/GAC system not only met all discharge limits set forth in the work plan, but the chlorinated hydrocarbons were reduced to concentrations below the 0.5 microgram per liter detection limit.

The only contaminants detected in the influent to the Grace treatment system were VOC, and all effluent VOC concentrations were below the 0.5 microgram per liter detection limit during Days 1 through 8. VOC detected in the effluent on Day 9 were attributable to variations of the UV radiation dosages during the optimization process.

The performance of the experimental reductive dehalogenation treatment technology was promising and will be evaluated further at the UniFirst property. As confirmed by EPA laboratory personnel, the automated VOC analytical system performed as designed, and is proposed to be integrated into the long term monitoring program for the Site. In combination, the Grace/UniFirst

recovery and treatment systems removed and destroyed VOC ground-water contaminants at an annualized rate of in excess of 100 gallons per year.

In summary, the pumping tests and pilot treatment systems were extremely successful and exceeded all of the predesign objectives identified in the ROD that were applicable to the UniFirst and Grace properties. These tests established that the proposed recovery systems will prevent migration of contaminants from source areas on the UniFirst and Grace properties, and will provide an efficient means of cleaning up the ground water in the Northeast Quadrant of the Wells G & H Site. Because the contaminated ground water will be prevented from migrating, the risk of public exposure to contaminated ground water from these sites will be eliminated. The pilot treatment systems reduced concentrations in the recovered ground water to below detectable levels without the creation of VOC air emissions or VOC-containing solids, and the innovative technologies tested showed great promise for greatly reducing treatment and analytical costs while achieving levels of performance higher than conventional technologies.

1.0 INTRODUCTION

1.1 Background Information

The work described in this report was performed by UniFirst Corporation (UniFirst) and W.R. Grace and Company - Conn. (Grace) pursuant to an Administrative Order by Consent, U.S. EPA docket number, I-90-1035 (Order) (EPA, 1990a). The remedial design that was performed pursuant to the Order, was initially conceived in part when Grace submitted to the EPA a work plan for a pilot-scale ground-water extraction and treatment system in July 1986. The negotiation of this work plan was interrupted in July 1988 when UniFirst submitted to the EPA a plan to perform a short-term (72 hour) pumping test on well UC22 on the UniFirst property. Well UC22 and its companion monitoring well UC9 provided preliminary indication that Well UC22 would be a likely candidate for a bedrock ground-water extraction well that would be capable of containing and removing all or a substantial part of the ground-water contamination on the UniFirst property and capturing off-property contaminated ground water.

EPA, in response to the request by UniFirst to perform the 72-hour pumping test at well UC22, notified Grace that the EPA would not take any additional action regarding the Grace proposed pilot-test until such time as the UniFirst 72-hour pumping-test was performed and the hydraulic effects known. The 72-hour pumping-test was performed by UniFirst in April 1988. Four major conclusions were derived from this test that would have substantive bearing on the source-area remedial actions at both the UniFirst and Grace properties. These conclusions are:

- (1) a pumping rate greater than the 20 gallons per minute rate of the 72-hour test could likely be sustained from well UC22;
- (2) water-level fluctuations in several monitoring wells indicated "nearby pumping effects." The location of the well or wells causing the cyclic fluctuations was not known;
- (3) the zone of influence of well UC22, and likely the zone of capture in the bedrock, extended beneath and down gradient of the Grace property. Therefore, it would be likely that pumping UC22 would, in addition to capturing all or substantial portions of the UniFirst plume, also capture all or substantial portions of the Grace plume; and

- (4) remedial actions at the Grace and UniFirst properties were hydraulically connected, and therefore may be better executed if combined into a coordinated remedial action.

UniFirst and Grace set aside their independent remedial programs and instead worked with the EPA to enter into an administrative order that would provide UniFirst and Grace with a means to proceed diligently with coordinated remedial design and remedial action for the respective properties. UniFirst and Grace sought issuance of the Order to expedite implementation of remedial action and the EPA acknowledged that UniFirst and Grace had performed lengthy and exhaustive investigatory work. This preliminary work enabled UniFirst and Grace to execute integrated pilot tests on each of their respective properties , and to submit to the EPA a 100 per cent final design of the remedial action for these source areas in this report.

The remedial design investigation and final design report presented here culminates a five-year effort begun with Grace's initial proposal for a pilot test on the Grace property through submission of the final design for the source-area remedial action on the UniFirst and Grace properties.

1.2 Report Objectives

The Work Plan for the remedial design investigation was prepared and the work described therein executed to develop information for and, ultimately, a final design for source-areas remedial action that would meet the objectives stated in the Order. These objectives are:

- (1) to prevent further migration of contaminated ground water from the source-areas to the Central-Area;
- (2) to restore the ground water in the vicinity of the source-areas to clean-up levels; and
- (3) to prevent public contact with contaminated ground water above the clean-up levels.

Based on these overall remedial objectives for the source-area remedial actions, UniFirst and Grace developed a specific set of objectives for the pumping tests and pilot treatability tests performed during the remedial design investigation. These specific objectives are:

- (1) to determine the combined hydraulic effect of pumping the 200 foot deep bedrock extraction well, UC22, on UniFirst's property and a group of unconsolidated deposits/shallow bedrock extraction wells on the Grace property;
- (2) to determine the appropriate treatment methods for the contaminated ground water at each property; and
- (3) to further characterize the existing ground-water quality within the northeastern quadrant of the Wells G & H Site.

These specific objectives, noted above, encompassed a substantially larger geographical area than the two specific properties. The scope of these objectives was extended because the 72-hour pumping test of UC22 had indicated that its zone of influence and probable zone of capture when pumped at 50 gallons per minute as proposed for the pilot test would extend far beyond the UniFirst and Grace properties. Therefore, it was appropriate to expand the study's specific objectives beyond those provided in the Order. Plate 1 is a map which shows principal areas of interest with respect to this remedial design report. The UniFirst and Grace properties are located in the upper right, or northeastern, corner of the map. Outlined on the map is an area herein referred to as the Northeast Quadrant. The Northeast Quadrant is an imprecisely defined area of approximately 70 acres which extends to the south and west of the UniFirst and Grace properties. The greatest effort of pilot test related data collection activities, such as well installation, ground water sampling and analysis, and water level measurements, occurred within the Northeast Quadrant. The Study Area refers to a larger portion of the Wells G & H Site within which water level measurements and other observations were also made as part of the 30-day extraction and pilot treatability testing. The locations of monitoring wells within the general boundaries of the Wells G & H Site are also shown on this map. Wells contained within the Study Area and Northeastern Quadrant boundaries were the principal locations of data collection used in this remedial design report.

While the study was more comprehensive than strictly required under the Order, the scope of this report is restricted to the remedial actions for the UniFirst and Grace properties. However, these two properties lie within an area designated by EPA as the Wells G & H Superfund Site which is the subject of a Consent Decree (EPA, 1990b). Much of the information developed through this remedial design investigation will have substantial bearing on other tasks assumed by UniFirst and Grace and other parties under the Consent Decree.

The Decree is carefully structured and fully accommodates other pertinent areas of concern. Under the Decree, for instance, remedial designs and actions within the Wells G & H Site must also be implemented for three other properties at which hazardous materials have been released.

A "Combined Effects" study will address the interactive effects of ground water pumping that may occur as a result of remedial actions at all the Consent Decree defined source-area properties.

Under the Decree, UniFirst, Grace and Beatrice Company have also agreed to perform a Central Area Remedial Investigation/Feasibility Study (RI/FS), to which much of the information assembled in this report will be relevant. In addition, the investigations that the EPA will undertake for Operable Unit 3, the so-called "River Study", will integrate the information from this limited-scope remedial design into the broader, comprehensive picture of the full Wells G & H Site.

1.3 Organization of the Report

The Remedial Design Investigation Report and Final Design for the UniFirst and Grace properties are organized into a three volume set. Volume I, Remedial Design Investigation Report, provides a full description of all the investigatory tasks undertaken prior to execution of the pumping and pilot treatability tests and the findings of the pumping and treatability tests. The last chapter presents the methodology for selecting and describes the selected final design for the ground water extraction and treatment systems for the UniFirst and Grace properties. Volume I also contains appendices that provide hard-copies of field data-gathering forms, geophysical data, and reports on the operation of the A+RT field organics analyzer and the performance of an experimental dehalogenation medium. In addition, the appendices to Volume I include computer disks that are formatted in IBM-PC compatible software that contain ground-water elevation data, ground-water chemistry data and the data from the A+RT field organics analyzer.

Volume II presents the final design for the UniFirst ground-water extraction and treatment system. Volume III presents the final design for the Grace ground-water extraction and treatment system. Volumes II and III have been written in parallel sections. The basic outline for these final design reports was taken from the Decree to provide a consistent and easily compared format for review. Both Volume II and Volume III provide appendices that include the various logs of operation and sampling, design calculations, health and safety data and residual management forms.

To facilitate cross-referencing among these volumes, appropriate sections, especially those that summarize the design basis for the remedial actions, have been repeated in appropriate sections. In addition, the full table of contents for all volumes is contained at the front of each volume.

Finally, the design drawings for the UniFirst and Grace plants are provided in rolled form, and they accompany each Volume II and Volume III provided to the EPA.

2.0 PRE-PUMPING CONDITIONS

2.1 Geology

The Wells G&H Site area is underlain by unconsolidated glacial deposits of Pleistocene age unconformably overlying crystalline bedrock of Paleozoic age. Wells G and H, located in the low central portion of the Aberjona River Valley, are in the buried valley where the fluvial-glacial deposits are greater than 100 feet thick and the bedrock surface is at an elevation less than zero feet NGVD. The Unifirst and Grace properties, located in the northeast section of the Wells G&H Site, are underlain primarily by till deposits which directly overlie bedrock. The bedrock surface rises steeply from an elevation less than -100 feet in the valley to an elevation greater than 100 feet near the intersection of Washington Street and Route 128.

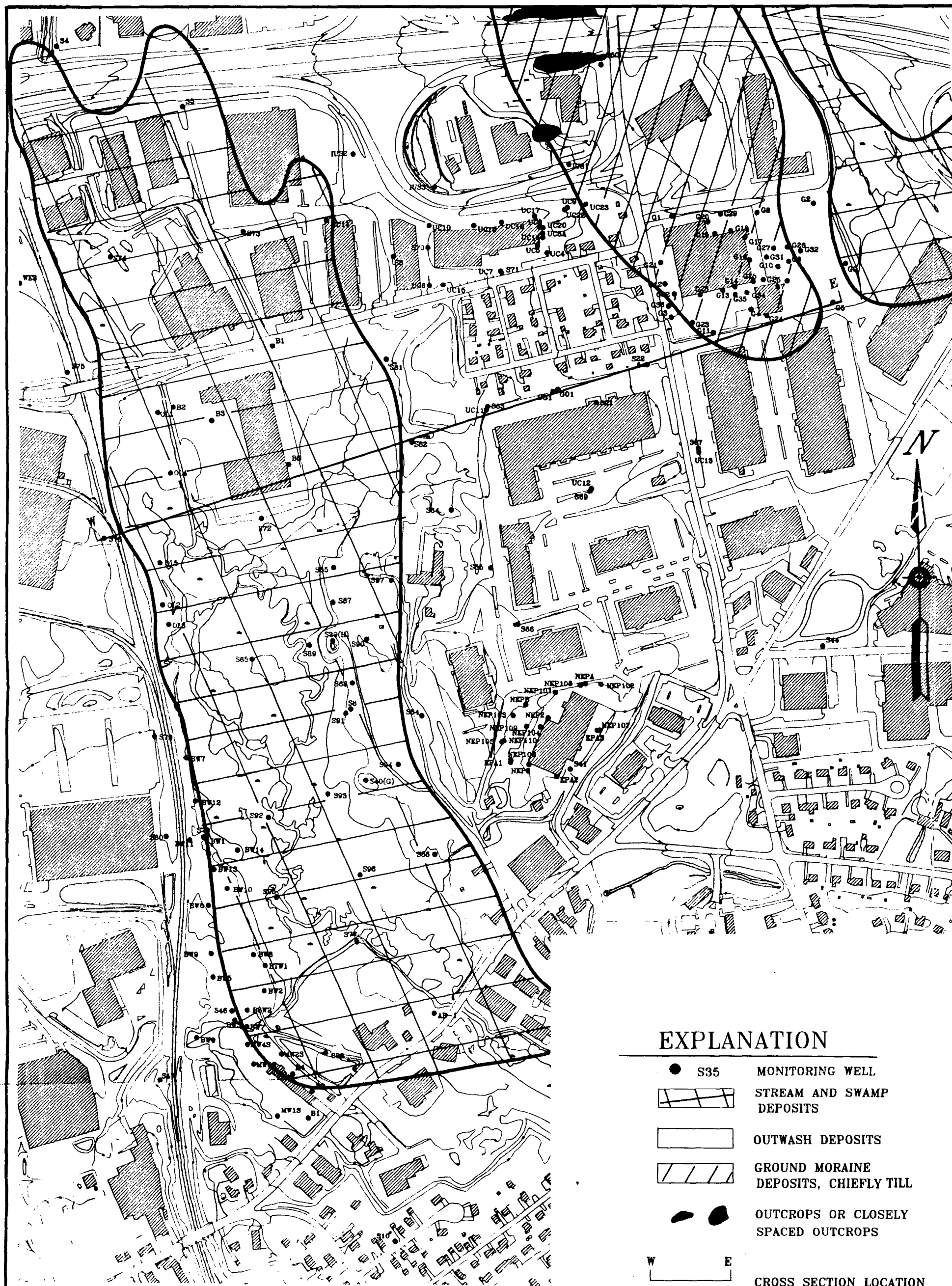
2.1.1 Surficial Geology

The unconsolidated deposits present at the Wells G&H Site can be divided into three types based on the mode of deposition. The three types of deposits are till, outwash, and recent swamp deposits. Figure 2.1-1 is a surficial geology map of the Site area showing the surficial expression of unconsolidated deposits.

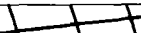




There are two tills, deposited directly from the glacial ice, which cover the upland areas of the site. A lodgment till, which lies directly on the bedrock surface, consists of a heterogeneous mixture of sand, silt, clay, gravel, cobbles, and boulders. This till laid down at the base of the glacier under the weight of ice, is very densely packed. Overlying the lodgment till is a thin layer of ablation till. The ablation till, released from the glacial ice as it melted, has a more sandy texture and is less densely packed than the lodgment till.

The central portion of the Site is underlain by outwash deposits. The outwash deposits consist of interbedded sand, gravel, cobbles, and silt. The outwash was deposited from meltwater streams flowing from the melting glacier. In the area between Washington Street and the eastern edge of the buried valley, the outwash deposits overlie the till and become thinner from west to east. Within the buried valley, the outwash deposits generally overlie the bedrock surface. In some areas, there is a thin layer of lodgment till between the outwash deposits and bedrock surface (deLing and Olimpio, 1989, p. 4).

Figure 2.1-2 is an east/west geologic section showing the stratigraphy of unconsolidated deposits beneath the Wells G&H Site area. The location of the section is shown on Figure 2.1-1.



EXPLANATION

- S35 MONITORING WELL
-  STREAM AND SWAMP DEPOSITS
-  OUTWASH DEPOSITS
-  GROUND MORaine DEPOSITS, CHIEFLY TILL
-  OUTCROPS OR CLOSELY SPACED OUTCROPS
-  CROSS SECTION LOCATION

DRAFT

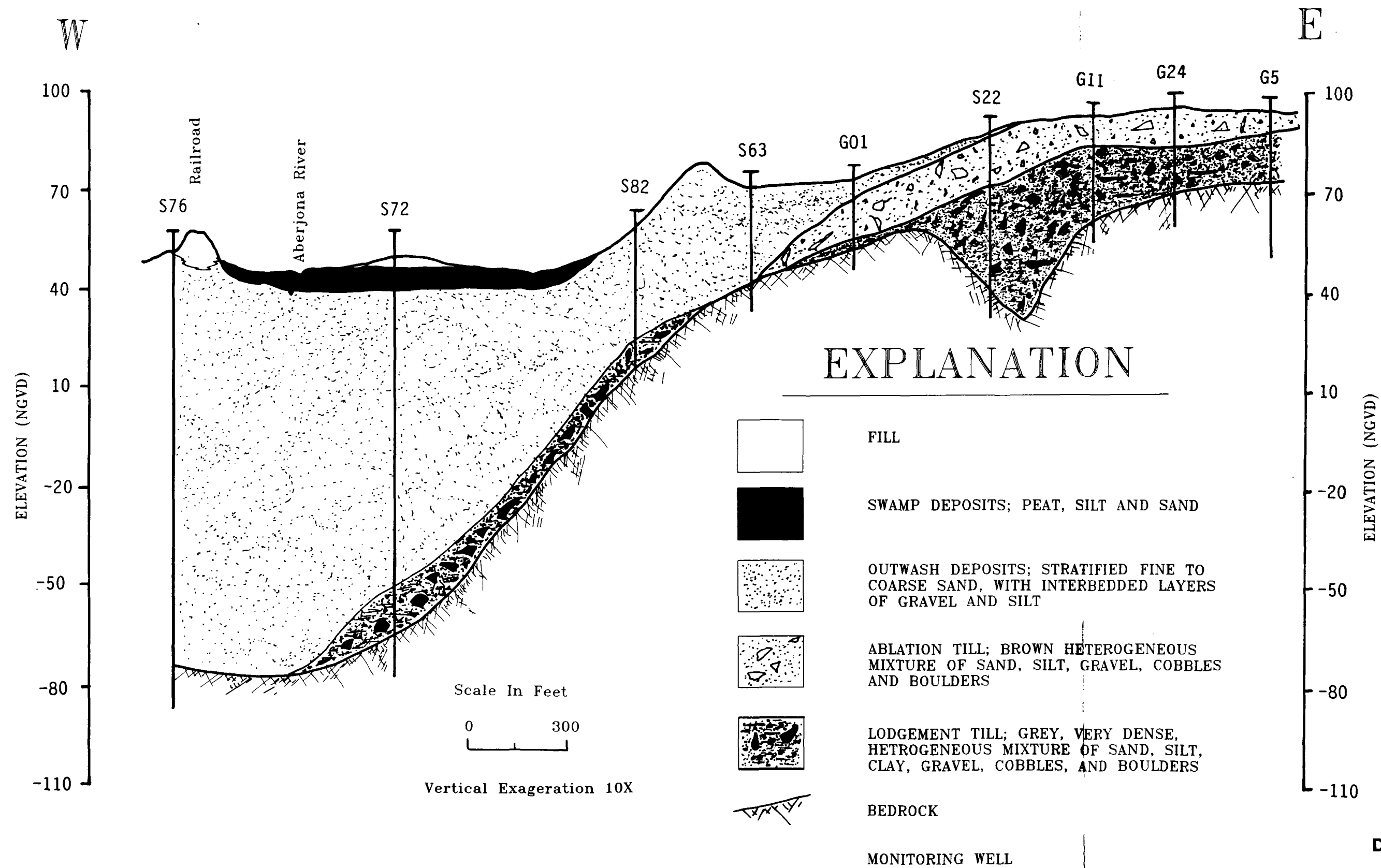
Surficial Geology Modified
After Chute, N.E.1959

Note: Base Map Prepared By Col-East
At A Scale Of 1 Inch = 100 Feet
From April 1990 Aerial Photographs

0 200 400 800
Scale In Feet

FIGURE 2.1-1

Surficial Geology of the
Wells G & H Site Area



DRAFT

FIGURE 2.1-2
West/East Geologic Cross-Section

2.1.2 Bedrock Geology

The bedrock underlying the Site area has been mapped as Salem Granodiorite, Dedham Granite, and undifferentiated metavolcanics (Barosh et al., 1977). Plate 2 shows the bedrock topography based on data from monitoring wells, borings, and seismic refraction surveys. The buried valley, located in the central portion of the site, is clearly shown as a northerly trending depression in the bedrock surface. In a northeasterly direction from the center of the valley is a series of depressions in the bedrock surface. Two deep bedrock wells, UG1 and G36, located near these depressions, encountered zones of very closely spaced fractures indicating faulting. The fractured rock observed in these boreholes and the linear depression in the bedrock surface likely reflect a fault zone within this area. The uneven bedrock topography observed in the Site area is likely the result of preferential erosion of fractured rock associated with the fault zones.

2.2 Hydrogeologic Characterization

To provide a better basis for evaluating the hydraulic effects of the planned pilot testing, an extensive field data collection program was designed and implemented. The purpose of the field investigations was to collect hydrogeologic information which would allow for a more detailed understanding of the geologic framework which controls ground-water movement as well as other factors which affect the hydrologic system. These data were collected prior to, during, and after cessation of the pilot test pumping of the UniFirst and Grace wells.

The hydrogeological characterization of the Northeast Quadrant of the Wells G & H Site included the following field investigation activities:

- drilling and installation of additional recovery and monitoring wells,
- well development,
- well integrity testing,
- geophysical surveys,
- a comprehensive well location and elevation survey,
- ground-water sampling and analysis, and
- ground-water elevation measurements.

Appendix A includes the field data collection forms documenting the procedures used for all of the pre-pumping field activities, such as hand water-level measurements, hydraulic testing, ground-water sampling, well integrity testing and well surveying. Appendices B and C include all hydrographs and data-logger data collected for the pilot test. Appendix D contains the boring

logs and well construction logs, Appendix E contains geophysical survey data, and Appendices F and G include ground-water quality data.

Each of these hydrogeologic characterization tasks is briefly described below with more detailed information included in the appropriate appendices.

2.2.1 Northeast Quadrant

Monitoring Well Installation

Drilling in the Northeast Quadrant included replacing bedrock monitoring well S65D with well S65DR. Well S65DR was drilled and constructed in the same manner as well S65D. The boring log and well construction details are included in Appendix D.

As part of the Central Area study of the Wells G & H Site, multi-port well UG1 was installed on the Cummings property. Well UG1 had seven ports which ranged in depth from 121 feet to 489 feet.

Well Integrity Testing

A well integrity test was conducted on each well which was planned to be used during the 30-day pilot test. Well integrity testing included checking the condition of the well, comparing existing well construction with the historical record, and monitoring the hydraulic response of the well. For purposes of the Pilot Test a well which did not meet the minimum performance criteria of well integrity testing would not be solely relied upon for hydraulic interpretations. The procedure for well integrity testing is outlined in Section 2.2 of the work plan and the well integrity test forms are included in Appendix A.

Monitoring wells within the Northeast Quadrant which did not pass well integrity testing included wells NEP102B and NEP109B. Monitoring well NEP109B was bent at the ground surface and could not be used. Monitoring wells G1DB3, G3DB2, and G3DB3, which are located on the Grace property, did not meet the minimum hydraulic response for the well integrity test. Monitoring points on the UniFirst property which did not pass the well integrity testing included wells UC9-1, UC9-3, and UC9-5. Monitoring well clusters S60 and S96 and well S65D could not be located in the field.

Ground-Water Sampling

An extensive ground-water sampling round was completed prior to the start of the 30-day pilot test. Samples were collected in February and March 1991. The objective of the sampling was

to provide a current baseline of chemical parameters within the Northeast Quadrant and to aid in the final design of the pilot test treatment system. The wells which were sampled as part of this areal sampling are listed on Table 2.2-1 and the parameters which were analyzed are listed on Tables 2.2-2 and 2.2-3.

Ground-water samples from eleven of the wells sampled in February and March 1991 were collected in the middle of the test and just before well UC22 stopped pumping. Table 2.2-4 lists the wells sampled. The samples were analyzed for VOC, total organic carbon, chloride, and nitrate/nitrite.

Samples were collected according to the procedures outlined in the Work Plan for the Remedial Design (April 12, 1991). The samples were submitted to Pace Laboratories of Wappinger Falls, New York. Laboratory data validation was completed by Trillium, Inc. of Coatesville, Pennsylvania. Laboratory methods and quality control/quality assurance procedures are presented in the QA/QC plan dated March 15, 1991.

The purge water from each well was collected and placed in lined steel drums and transported to secure areas on the UniFirst or Grace properties. The purge water was subsequently treated in the pilot treatment plants and discharged. The contents, storage, and ultimate disposal of the material in the drums were documented and are included in Appendix A.

Surveying

A comprehensive third-order vertical and horizontal well survey was completed for over 200 wells in the Wells G & H Site. The surveyed wells are listed in Table 2.2-5. The surveying was completed between November 28 and December 12, 1990, by a registered surveyor from the BSC Group of Bedford, Massachusetts. Monitoring wells which were installed after December 12, 1990, were surveyed in April 1991. The surveyed locations of the wells are included on Plate 1. A table listing well locations and elevations is included in Appendix A.

Water-Level Monitoring

Water-level measurements were collected from 248 wells before, during, and after the 30-day pilot test. Water-level measurement frequency ranged from approximately ten day intervals for wells located distant from the UniFirst and Grace extraction wells to daily for wells located in closer proximity to the pilot test extraction wells. "Continuous" water level monitoring was also done in several monitoring wells using chart recorders in addition to pressure transducers and data loggers. Data loggers were programmed to record at fifteen minute intervals. The wells which were measured, the method of measurement, measurement frequency, and period of

TABLE 2.2-1

Wells Sampled Between February and March 1991
and Analyzed for the Parameters
Listed in Table 2.2-2

S63S	IUS1	UC12-1	S21
S63D	IUS2A	UC12-4	S22
S64S	IUS2B	UC12-6	S65S
S64M	IUS2C	UC13-1	S65M
S64D	IUS3A	UC13-2	S65DR
S67S	IUS3B	UC13-3	G01S
S67M	IUS3C	UC13-4	G01D
S67D	UC5	UC14-1	G01DB
S69D	UC6	UC14-2	G36DB2
S71S	UC7-1	UC14-3	G3D
S71D	UC7-2	UC14-4	RW3
S73D	UC7-3	UC14-5	
S81S	UC11-1 ¹	UC18	
S81M	UC11-2	UC23-1	
S81D	UC11-4 ¹	UC23-2	
S82		UC23-3	
		UC23-4	
		UC23-5	
		UC23-6	

Notes:

¹ Sampled for VOC only.

TABLE 2.2-2

Parameters Analyzed from
Ground-Water Samples Obtained from
Monitoring Wells in Table 2.2-1

<u>Parameter</u>	<u>Reference</u>
Volatile Organic Compounds	TCL CLP SOW 2/88*
Semivolatile Organic Compounds	TCL CLP SOW 2/88
Pesticides/PCBs	TCL CLP SOW 2/88
Metals - Soluble	TAL CLP SOW 7/88
Metals - Total	TAL CLP SOW 7/88
Silica - soluble	
Nitrite and Nitrate - Soluble	
Sulfate - Soluble	
Fluoride - Soluble	
Chloride - Soluble	
Phosphate - Total	
Alkalinity - Soluble	
Total Organic Carbon	
Total Dissolved Solids	
Radionuclides	

*TCL CLP SOW 2/88 with 9/88, 4/89 and 5/89 revisions (CLP SOW 2/88)

TABLE 2.2-3

Analyte List
Fresh Water Chronic Criteria for Aquatic Life
(all concentrations in micrograms per liter)

Volatiles	FWCCAL	Semi-volatiles	FWCCAL	Semi-volatiles (cont)	FWCCAL	Pesticides/PCBs	FWCCAL	Metals	FWCCAL
Vinyl chloride	*	Phenol	2560	2,4-Dinitrotoluene	*	alpha-BHC	(i)	Aluminum	*
Chloroethane	*	bis(2-Chloroethyl)ether	*	Diethylphthalate	(g)	beta-BHC	(i)	Antimony	1800
Methylene chloride	(b)	2-Chlorophenol	2000	4-Chlorophenyl-phenyl ether	*	delta-BHC	(i)	Arsenic (tri-)	190
1,1-Dichloroethene	*	1,3-Dichlorobenzene	(e)	Fluorene	(h)	gamma-BHC (lindane)	0.08	(pent-)	48
1,1-Dichloroethane	*	1,4-Dichlorobenzene	(e)	4-Nitroaniline	*	Heptachlor	0.0036	Barium	*
trans-1,2-Dichloroethene	*	Benzyl alcohol	*	4,6-Dinitro-2-methylphenol	*	Aldrin	*	Beryllium	5.3
cis-1,2-Dichloroethene	*	1,2-Dichlorobenzene	(e)	N-nitrosodiphenylamine	*	Heptachlor epoxide	*	Cadmium	1.1 +
Chloroform	1240	2-Methylphenol	*	4-Bromophenyl-phenyl ether	*	Endosulfan I	0.056	Calcium	*
1,2-Dichloroethane	20000	bis(2-Chloroisopropyl)ether	*	Hexachlorobenzene	*	Dieldrin	0.0019	Chromium (tri-)	210 +
1,1,1-Trichloroethane	(d)	4-Methylphenol	*	Pentachlorophenol	13 + +	4,4-DDE	*	(hex-)	11
Carbon tetrachloride	*	N-nitroso-di-n-propylamine	*	Phenanthrene	(h)	Endrin	0.0023	Cobalt	*
Bromodichloromethane	(b)	Hexachloroethane	540	Anthracene	(h)	Endosulfan II	0.056	Copper	12 +
1,2-Dichloropropane	5700	Nitrobenzene	*	Di-n-butylphthalate	(g)	4,4-DDD	*	Iron	*
cis-1,3-Dichloropropene	244	Isophorone	*	Fluoranthene	(h)	Endosulfan sulfate	*	Lead	3.2 +
Trichloroethene	21900	2-Nitrophenol	(f)	Pyrene	(h)	4,4-DDT	0.001	Magnesium	*
Dibromochloromethane	(b)	2,4-Dimethylphenol	*	Butylbenzylphthalate	(g)	Methoxychlor	0.03	Manganese	*
1,1,2-Trichloroethane	9400	Benzoic acid	*	3,3'-Dichlorobenzidine	*	Endrin ketone	*	Mercury	0.012
Benzene	*	bis(2-Chloroethoxy)methane	*	Benzo(a)anthracene	(h)	alpha-Chlordane	0.004	Nickel	160 +
trans-1,3-Dichloropropene	244	2,4-Dichlorophenol	365	Chrysene	(h)	gamma-Chlordane	0.004	Potassium	*
Bromoform	(b)	1,2,4-Trichlorobenzene	*	bis(2-Ethylhexyl)phthalate	(g)	Toxaphene	0.0002	Selenium	36
Tetrachloroethene	940	Naphthalene	620	Di-n-octylphthalate	(g)	Aroclor-1016	(j)	Silver	0.12
Toluene	*	4-Chloroaniline	*	Benzo(b)fluoranthene	(h)	Aroclor-1221	(j)	Sodium	*
1,1,2,2-Tetrachloroethane	2400	Hexachlorobutadiene	9.3	Benzo(k)fluoranthene	(h)	Aroclor-1232	(j)	Thallium	40
Chlorobenzene	(a)	4-Chloro-3-methylphenol	*	Benzo(a)pyrene	(h)	Aroclor-1242	(j)	Vanadium	*
Ethylbenzene	*	2-Methylnaphthalene	*	Indeno(1,2,3-cd)pyrene	(h)	Aroclor-1248	(j)	Zinc	110 +
o-Xylene	*	Hexachlorocyclopentadiene	5.2	Dibenz(a,h)anthracene	(h)	Aroclor-1254	(j)		
m-, p-Xylene	*	2,4,6-Trinitrophenol	*	Benzo(g,h,i)perylene	(h)	Aroclor-1260	(j)		
		2,4,5-Trinitrophenol	*					Inorganics	
Volatile Groups		2-Chloronaphthalene	*	Semi-volatile Groups		Pesticide Groups		Cyanide	5.2
Chlorinated benzenes (a)	50	2-Nitroaniline	*	Dichlorobenzenes (e)	763	BHCs (i)	*	Silica	*
Halomethanes (b)	*	Dimethylphthalate	(g)	Nitrophenols (f)	150	PCBs (j)	0.014	Nitrite	*
Tetrachloroethanes (c)	*	Acenaphthylene	*	Phthalate esters (g)	3			Nitrate	*
Trichloroethanes (d)	*	2,6-Dinitrotoluene	*	PAHs (h)	*	Radionuclides		Sulfate	*
		3-Nitroaniline	*			Gross alpha	*	Fluoride	*
		Acenaphthene	520			Radium 226/228	*	Chloride	*
		2,4-Dinitrophenol	*			Beta particle	*	Phosphate	*
		4-Nitrophenol	(f)			Radon	*	Alkalinity	*
		Dibenzofuran	*			Uranium	*	Others	
								TOC	*
								TDS	*

* : No criteria established

Update #2 to "Quality Criteria for Water 1986", May 1, 1987.

(a-j) : Groups of chemicals for which the criteria is a cumulative total.

+ : Hardness dependant criteria (100 mg/L used).

+ + : pH dependant criteria (7.8 pH used).

TABLE 2.2-4
Wells Sampled During the Pilot Test

UC14-1

UC14-5

UC7-2

UC23-3

G01DB

UG1-6

UG1-2

UC11-2

S82

S81S

UC18

Total 11

Note: 1. Wells listed above were analyzed for VOC, TOC, Cl, NO₂, NO₃
2. Samples were collected midway through and again at the end of the test.

TABLE 2.2-5

Water-Level Monitoring and
Well Construction Information

	<u>Well ID</u>	<u>Ground Elev.</u>	<u>Geologic Unit Screened¹</u>	<u>Well Depth²</u>	<u>TOS Elev.³</u>	<u>BOS Elev.⁴</u>	<u>Measurement Frequency⁵</u>	<u>Type of Monitoring Equipment⁶</u>	<u>Period of Water Level Measurement</u>	<u>Sampled in 1991</u>
2-11	S5	52.5	DR/SHB	66	50	-12	5	ET	4/25-5/30	N
	S6	62.2	DR/SHB	94	54	-37	D	ET	4/25-5/30	N
	S7	94.8	DR/SHB	28	91	67	5	ET	4/25-5/30	N
	S8	45.1	DR/SHB	128	41	-84	5	ET	4/25-5/30	N
	S21	77.7	DR/SHB	32	73	46	D	ET	4/25-5/30	Y
	S22	85.0	DR/SHB	44	80	40	D	ET	4/25-5/30	Y
	S39	51.9	DR	88	-35	-45	5	ET	4/25-5/30	N
	S40	52.3	DR	79	-26	-36	5	ET	4/25-5/30	N
	S63D	69.8	SHB	36	44	34	L	PT/DL	4/25-5/30	Y
	S63S	69.9	DR	22	58	48	L	PT/DL	4/25-5/30	Y
	S64D	57.5	SHB	55	18	3	D	ET	4/25-5/30	Y
	S64M	57.4	DR	32	31	26	D	ET	4/25-5/30	Y
	S64S	57.3	DR	15	48	43	D	ET	4/25-5/30	Y
	S65DR	77.6	SHB	57	31	21	D	ET	4/25-5/30	Y
	S65M	76.3	DR	37	50	40	D	ET	4/25-5/30	Y
	S65S	76.6	DR	24	73	53	D	ET	4/25-5/30	Y
	S66	70.1	SHB	35	50	35	D	ET	4/25-5/30	N

TABLE 2.2-5 (continued)

<u>Well ID</u>	<u>Ground Elev.</u>	<u>Geologic Unit Screened¹</u>	<u>Well Depth²</u>	<u>TQS Elev.³</u>	<u>BQS Elev.⁴</u>	<u>Measurement Frequency⁵</u>	<u>Type of Monitoring Equipment⁶</u>	<u>Period of Water Level Measurement</u>	<u>Sampled in 1991</u>
S67D	83.2	SHB	75	23	8	L	PT/DL	4/15-6/17	Y
S67M	83.3	DR	43	50	40	D	ET	4/25-5/30	Y
S67S	83.3	DR	34	59	49	L	PT/DL	4/15-6/17	Y
S68D	45.5	DR	105	-9	-59	5	ET	4/25-5/30	N
S68S	45.2	DR	45	31	0	5	ET	4/25-5/30	N
S69D	75.6	SHB	55	35	20	D	ET	4/25-5/30	Y
S70D	69.9	SHB	82	2	-13	D	ET	4/25-5/30	N
S70M	70.0	DR	62	27	7	D	ET	4/25-5/30	N
S70S	70.0	DR	30	54	39	D	ET	4/25-5/30	N
S71D	71.3	SHB	43	49	29	D	ET	4/25-5/30	Y
S71S	71.4	DR	16	60	55	D	ET	4/25-5/30	Y
S72D	49.1	SHB	137	-72	-87	5	ET	4/25-5/30	N
S72M	50.6	DR	92	-4	-42	5	ET	4/25-5/30	N
S72S	51.1	DR	54	17	-3	5	ET	4/25-5/30	N
S73D	52.7	SHB	56	12	-4	5	ET	4/25-5/30	Y
S73S	52.6	DR	35	42	17	D	ET	4/25-5/30	N
S74D	47.8	SHB	88	-25	-40	5	ET	4/25-5/30	N
S74S	47.8	DR	58	40	-10	5	ET	4/25-5/30	N
S81D	53.8	SHB	82	-13	-28	D	ET	4/25-5/30	Y

TABLE 2.2-5 (continued)

<u>Well ID</u>	<u>Ground Elev.</u>	<u>Geologic Unit Screened¹</u>	<u>Well Depth²</u>	<u>TOS Elev.³</u>	<u>BOS Elev.⁴</u>	<u>Measurement Frequency⁵</u>	<u>Type of Monitoring Equipment⁶</u>	<u>Period of Water Level Measurement</u>	<u>Sampled in 1991</u>
S81M	55.0	DR	50	20	5	D	ET	4/25-5/30	Y
S81S	54.2	DR	20	44	34	D	ET	4/25-5/30	Y
S82	56.9	DR	35	32	22	D	ET	4/25-5/30	Y
S84D	46.0	DR	78	-27	-32	5	ET	4/25-5/30	N
S84M	45.9	DR	45	6	1	5	ET	4/25-5/30	N
S84S	45.9	DR	18	33	28	5	ET	4/25-5/30	N
S85M	46.1	DR/SHB	71	-19	-25	5	ET	4/25-5/30	N
S85S	46.0	DR	30	26	16	5	ET	4/25-5/30	N
S86D	44.3	DR	52	-4	-9	5	ET	4/25-5/30	N
S86S	44.4	DR	30	18	13	5	ET	4/25-5/30	N
S87D	45.6	DR	80	-30	-34	5	ET	4/25-5/30	N
S87M	46.3	DR	40	10	6	5	ET	4/25-5/30	N
S87S	45.4	DR	10	39	35	5	ET	4/25-5/30	N
S88D	44.2	DR	80	-32	-36	5	ET	4/25-5/30	N
S88M	44.2	DR	40	8	4	5	ET	4/25-5/30	N
S88S	44.2	DR	10	38	34	5	ET	4/25-5/30	N
S89D	43.8	DR	120	-72	-76	5	ET	4/25-5/30	N
S89M	43.8	DR	56	-8	-12	5	ET	4/25-5/30	N
S89S	43.8	DR	32	16	12	5	ET	4/25-5/30	N

TABLE 2.2-5 (continued)

<u>Well ID</u>	<u>Ground Elev.</u>	<u>Geologic Unit Screened¹</u>	<u>Well Depth²</u>	<u>TOS Elev.³</u>	<u>BOS Elev.⁴</u>	<u>Measurement Frequency⁵</u>	<u>Type of Monitoring Equipment⁶</u>	<u>Period of Water Level Measurement</u>	<u>Sampled in 1991</u>
S90D	47.3	DR/SHB	74	-14	-27	5	ET	4/25-5/30	N
S90M	47.2	DR	40	13	7	5	ET	4/25-5/30	N
S90S	47.3	DR	10	41	37	5	ET	4/25-5/30	N
S91D	44.4	DR	80	-32	-36	5	ET	4/25-5/30	N
S91M	44.7	DR	40	9	5	5	ET	4/25-5/30	N
S91S	45.3	DR	10	39	35	5	ET	4/25-5/30	N
S93D	43.4	DR	80	-33	-37	5	ET	4/25-5/30	N
S93M	43.4	DR	45	3	-2	5	ET	4/25-5/30	N
S93S	43.4	DR	15	32	28	5	ET	4/25-5/30	N
S94D	45.9	DR	80	-29	-34	5	ET	4/25-5/30	N
S94M	46.1	DR	40	10	6	5	ET	4/25-5/30	N
S94S	45.8	DR	15	35	31	5	ET	4/25-5/30	N
S95D	43.0	DR	80	-33	-37	5	ET	4/25-5/30	N
S95M	43.0	DR	40	7	3	5	ET	4/25-5/30	N
S95S	43.0	DR	15	35	28	5	ET	4/25-5/30	N
S97D	48.6	SHB	44	7	5	5	ET	4/25-5/30	N
S97M	48.5	DR	26	26	22	5	ET	4/25-5/30	N
S97S	48.9	DR	15	41	34	5	ET	4/25-5/30	N
IUS1	87.6	SHB	26	76	61	D	ET	4/25-5/30	Y

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TABLE 2.2-5 (continued)

<u>Well ID</u>	<u>Ground Elev.</u>	<u>Geologic Unit Screened</u> ¹	<u>Well Depth</u> ²	<u>TOS Elev.</u> ³	<u>BQS Elev.</u> ⁴	<u>Measurement Frequency</u> ⁵	<u>Type of Monitoring Equipment</u> ⁶	<u>Period of Water Level Measurement</u>	<u>Sampled in 1991</u>
IUS2A	61.4	SHB	89	-10	-28	D	ET	4/25-5/30	Y
IUS2B	61.2	DR	55	21	6	D	ET	4/25-5/30	Y
IUS2C	61.2	DR	20	51	41	D	ET	4/25-5/30	Y
IUS3A	66.7	DR/SHB	63	20	4	L	PT/DL	4/15-6/17	Y
IUS3B	67.0	DR	45	37	22	L	PT/DL	4/15-6/17	Y
IUS3C	67.0	DR	25	62	42	D	ET	4/25-5/30	Y
UC4	73.6	SHB	20	64	54	D	ET	4/25-5/30	N
UC5	73.0	DR/SHB	19	64	54	H	PT/DL	4/25-5/30	Y
UC6	68.3	DR	43	35	25	D	ET	4/25-5/30	Y
UC7A1	71.0	DPB	133	-60	-77	H/D	ET	4/25-5/30	Y
UC7A2	71.0	DPB	104	-21	-46	H/D	ET	4/25-5/30	Y
UC7A3	71.0	DPB	77	6	-18	H/D	ET	4/25-5/30	Y
UC7A4	71.0	SHB	41	50	9	H/D	ET	4/25-5/30	N
UC7A5	71.0	DR	16	71	53	H/D	ET	4/25-5/30	N
UC8	74.2	DR/SHB	21	69	54	D	ET	4/25-5/30	N
UC9-2	84.5	DPB	181	-86	-97	D/3	AL	4/25-5/30	N
UC9-4	84.5	DPB	113	-18	-28	D/3	AL	4/25-5/30	N
UC9-6	84.5	SHB	37	67	47	D/3	AL	4/25-5/30	N
UC10-1	69.6	DPB	243	-161	-173	D/3	AL	4/25-5/30	N

TABLE 2.2-5 (continued)

<u>Well ID</u>	<u>Ground Elev.</u>	<u>Geologic Unit Screened¹</u>	<u>Well Depth²</u>	<u>TQS Elev.³</u>	<u>BQS Elev.⁴</u>	<u>Measurement Frequency⁵</u>	<u>Type of Monitoring Equipment⁶</u>	<u>Period of Water Level Measurement</u>	<u>Sampled in 1991</u>
UC10-2	69.6	DPB	227	-145	-157	D/3	AL	4/25-5/30	N
UC10-3	69.6	DPB	182	-102	-112	D/3	AL	4/25-5/30	N
UC10-4	69.6	DPB	158	-78	-88	D/3	AL	4/25-5/30	N
UC10-5	69.6	DPB	128	-55	-59	D/3	AL	4/25-5/30	N
UC10-6	69.6	DPB	93	-8	-23	D/3	AL	4/25-5/30	N
UC11-1	70.2	DPB	335	-250	-264	D/3	AL	4/25-5/30	Y
UC11-2	70.2	DPB	273	-183	-203	D/3	AL	4/25-5/30	Y
UC11-4	70.2	DPB	173	-96	-103	D/3	AL	4/25-5/30	Y
UC11-6	70.2	DPB	52	29	19				N
UC12-1	74.8	DPB	340	-238	-268	D/3	AL	4/25-5/30	Y
UC12-4	74.8	DPB	159	-72	-84	D/3	AL	4/25-5/30	Y
UC12-5	74.8	DPB	94	-3	-20				N
UC12-6	74.8	DPB	58	24	16	D/3	AL	4/25-5/30	Y
UC13-1	83.3	DPB	213	-96	-272	none	none	-	-
UC13-2	83.3	DPB	152	-59	-69	none	none	-	Y
UC13-3	83.3	DPB	114	-20	-31	none	none	-	Y
UC13-4	83.3	DPB	72	21	11	none	none	-	Y
UC14-1	59.1	DPB	339	-267	-280	D/3	AL	4/25-5/30	Y
UC14-2	59.1	DPB	295	-223	-236	D/3	AL	4/25-5/30	Y

TABLE 2.2-5 (continued)

<u>Well ID</u>	<u>Ground Elev.</u>	<u>Geologic Unit Screened</u> ¹	<u>Well Depth</u> ²	<u>TQS Elev.</u> ³	<u>BQS Elev.</u> ⁴	<u>Measurement Frequency</u> ⁵	<u>Type of Monitoring Equipment</u> ⁶	<u>Period of Water Level Measurement</u>	<u>Sampled in 1991</u>
UC14-3	59.1	DPB	236	-164	-176	D/3	AL	4/25-5/30	Y
UC14-4	59.1	DPB	157	-86	-98	D/3	AL	4/25-5/30	Y
UC14-5	59.1	DPB	98	-17	-39	D/3	AL	4/25-5/30	Y
UC15S	68.4	DPB	88	-10	-20	H	PT/DL	4/25-5/30	N
UC15D	68.4	DPB	280	-202	-212	H	PT/DL	4/25-5/30	N
UC16	72.8	SHB	28	62	44	H	PT/DL	4/25-5/30	N
UC17	73.5	SHB	30	62	44	H/D	ET	4/25-5/30	N
UC18	73.2	SHB	33	60	40	H/D	ET	4/25-5/30	Y
UC19	70.9	SHB	59	31	12	H/D	ET	4/25-5/30	N
UC20	73.1	SHB	27	65	46	H/D	ET	4/25-5/30	N
UC22	84.7	SHB	190	70	-105	H	PT/DL	4/25-5/30	Y
UC23-1	91.1	DPB	400	-303	-308	D	ET	4/25-5/30	Y
UC23-2	91.1	DPB	384	-283	-293	D	ET	4/25-5/30	Y
UC23-3	91.1	DPB	304	-197	-213	D	ET	4/25-5/30	Y
UC23-4	91.1	DPB	265	-164	-174	D	ET	4/25-5/30	Y
UC23-5	91.1	DPB	243	-141	-152	D	ET	4/25-5/30	Y
UG1-1	73.1	DPB	489	-413	-427	D/3	ET	4/25-5/30	N
UG1-2	73.1	DPB	481	-397	-408	D/3	ET	4/25-5/30	Y
UG1-3	73.1	DPB	390	-301	-317	D/3	ET	4/25-5/30	Y

TABLE 2.2-5 (continued)

<u>Well ID</u>	<u>Ground Elev.</u>	<u>Geologic Unit Screened¹</u>	<u>Well Depth²</u>	<u>TQS Elev.³</u>	<u>BQS Elev.⁴</u>	<u>Measurement Frequency⁵</u>	<u>Type of Monitoring Equipment⁶</u>	<u>Period of Water Level Measurement</u>	<u>Sampled in 1991</u>
UG1-4	73.1	DPB	227	-143	-154	D/3	ET	4/25-5/30	Y
UG1-5	73.1	DPB	172	-91	-99	D/3	ET	4/25-5/30	Y
UG1-6	73.1	DPB	159	-75	-86	D/3	ET	4/25-5/30	Y
UG1-7	73.1	DPB	121	-38	-48	D/3	ET	4/25-5/30	Y
G1D	97.8	SHB	52	56	46	D	ET	4/25-5/30	N
G1DB	97.1	DPB	96	7	2	D	ET	4/25-5/30	N
G1DB2	97.0	DPB	140	-37	-42	D	ET	4/25-5/30	Y
G1DB3	97.1	DPB	190	-87	-92	D	ET	4/25-5/30	Y
G1S	97.5	DR	36	71	61	D	ET	4/25-5/30	N
G01D	73.4	SHB	35	49	38	L	PT/DL	4/15-7/9	Y
G01DB	73.3	DPB	70	18	3	L	PT/DL	4/15-7/9	Y
G01S	73.4	DR	18	65	55	L	PT/DL	4/15-7/9	Y
G2D	97.6	SHB	50	58	48	D	ET	4/25-5/30	N
G2M	97.4	DR	28	74	69	D	ET	4/25-5/30	N
G2S	97.8	DR	19	89	79	D	ET	4/25-5/30	N
G3D	91.0	SHB	61	45	30	H	PT/DL	4/25-5/30	N
G3DB	91.3	DPB	100	6	-9	H	PT/DL	4/25-5/30	Y
G3DB2	90.8	DPB	158	-63	-68	H	PT/DL	4/25-5/30	Y
G3S	91.1	DR	37	69	54	D	ET	4/25-5/30	Y

TABLE 2.2-5 (continued)

<u>Well ID</u>	<u>Ground Elev.</u>	<u>Geologic Unit Screened¹</u>	<u>Well Depth²</u>	<u>TOS Elev.³</u>	<u>BQS Elev.⁴</u>	<u>Measurement Frequency⁵</u>	<u>Type of Monitoring Equipment⁶</u>	<u>Period of Water Level Measurement</u>	<u>Sampled in 1991</u>
G4D	93.4	SHB	44	64	49	D	ET	4/25-5/30	N
G4S	93.7	DR	26	78	68	D	ET	4/25-5/30	N
G5D	93.6	SHB	41	68	53	D	ET	4/25-5/30	N
G5S	93.4	DR	21	82	72	D	ET	4/25-5/30	N
G6S	96.7	DR	11	ND	86	D	ET	4/25-5/30	N
G7D	96.3	SHB	51	60	45	D	ET	4/25-5/30	N
G7S	96.6	DR	21	91	76	D	ET	4/25-5/30	N
G8S	98.8	DR	44	64	54	D	ET	4/25-5/30	N
G9S	95.3	DR	18	82	77	D	ET	4/25-5/30	N
G10S	97.0	DR	25	82	72	D	ET	4/25-5/30	N
G10D	97.0	SHB	44	67	52	D	ET	4/25-5/30	N
G10DB	96.8	DPB	100	12	-3	D	ET	4/25-5/30	N
G11D	91.1	SHB	44	62	47	D	ET	4/25-5/30	Y
G11S	91.4	DR	21	75	70	D	ET	4/25-5/30	Y
G12D	93.6	SHB	46	58	48	H	PT/DL	4/15-7/9	Y
G12S	93.5	DR	25	79	69	D	ET	4/25-5/30	Y
G13D	94.0	SHB	52	57	42	H	PT/DL	4/25-5/30	Y
G13S	94.0	DR	27	77	67	D	ET	4/25-5/30	Y
G14D	94.2	SHB	43	67	52	H	PT/DL	4/25-5/30	N

TABLE 2.2-5 (continued)

<u>Well ID</u>	<u>Ground Elev.</u>	<u>Geologic Unit Screened</u> ¹	<u>Well Depth</u> ²	<u>TQS Elev.</u> ³	<u>BOS Elev.</u> ⁴	<u>Measurement Frequency</u> ⁵	<u>Type of Monitoring Equipment</u> ⁶	<u>Period of Water Level Measurement</u>	<u>Sampled in 1991</u>
G14S	94.2	DR	22	82	72	D	ET	4/25-5/30	N
G15D	97.8	SHB	46	72	51	H	PT/DL	4/25-5/30	Y
G15S	97.7	DR	24	84	74	D	ET	4/25-5/30	Y
G16D	98.0	SHB	59	54	39	D	ET	4/25-5/30	Y
G16S	97.9	DR	30	78	68	D	ET	4/25-5/30	Y
G17D	98.0	SHB	72	41	26	D	ET	4/25-5/30	N
G17S	98.0	DR	47	61	51	D	ET	4/25-5/30	N
G18D	98.1	SHB	52	61	46	D	ET	4/25-5/30	N
G18S	98.1	DR	32	76	66	D	ET	4/25-5/30	N
G19D	98.0	SHB	74	39	24	D	ET	4/25-5/30	N
G19M	98.1	DR	44	64	54	D	ET	4/25-5/30	N
G19S	98.0	DR	20	88	78	D	ET	4/25-5/30	N
G20D	97.0	SHB	85	27	12	D	ET	4/25-5/30	N
G20M	97.0	DR	58	49	39	D	ET	4/25-5/30	N
G20S	96.9	DR	35	72	62	D	ET	4/25-5/30	N
G21D	95.1	SHB	49	61	46	L	PT/DL	4/15-7/9	Y
G21S	95.3	DR	29	76	66	L	PT/DL	4/15-7/9	Y
G22D	93.9	SHB	52	57	42	H	PT/DL	4/15-7/9	Y
G22S	94.0	DR	32	77	62	D	ET	4/25-5/30	Y

TABLE 2.2-5 (continued)

<u>Well ID</u>	<u>Ground Elev.</u>	<u>Geologic Unit Screened¹</u>	<u>Well Depth²</u>	<u>TOS Elev.³</u>	<u>BOS Elev.⁴</u>	<u>Measurement Frequency⁵</u>	<u>Type of Monitoring Equipment⁶</u>	<u>Period of Water Level Measurement</u>	<u>Sampled in 1991</u>
G23D	91.4	SHB	48	59	44	D	ET	4/25-5/30	Y
G23S	91.3	DR	26	75	65	D	ET	4/25-5/30	Y
G24D	96.3	SHB	47	64	49	D	ET	4/25-5/30	N
G24S	96.4	DR	26	80	70	D	ET	4/25-5/30	N
G25S	97.4	DR	30	77	67	D	ET	4/25-5/30	N
G25D	97.3	SHB	48	65	50	H	PT/DL	4/25-5/30	N
G26D	97.5	SHB	42	70	55	D	ET	4/25-5/30	N
G26S	97.6	DR	21	86	76	D	ET	4/25-5/30	N
G27D	97.6	SHB	40	72	57	D	ET	4/25-5/30	N
G27S	97.5	DR	21	86	76	D	ET	4/25-5/30	N
G28D	94.0	SHB	44	64	50	H	PT/DL	4/25-5/30	N
G28S	94.0	DR	25	79	69	D	ET	4/25-5/30	N
G29S	96.6	DR	24	87	72	D	ET	4/25-5/30	N
G31D	97.7	SHB	48	64	49	D	ET	4/25-5/30	N
G31S	97.4	DR	28	80	70	D	ET	4/25-5/30	N
G32S	97.8	DR	26	82	72				N
G34D	93.9	SHB	37	67	57	H	PT/DL	4/25-5/30	Y
G34S	94.0	DR	22	82	72	D	ET	4/25-5/30	Y
G35D	93.9	SHB	38	65	55	H	PT/DL	4/25-5/30	Y

TABLE 2.2-5 (continued)

<u>Well ID</u>	<u>Ground Elev.</u>	<u>Geologic Unit Screened¹</u>	<u>Well Depth²</u>	<u>TOS Elev.³</u>	<u>BOS Elev.⁴</u>	<u>Measurement Frequency⁵</u>	<u>Type of Monitoring Equipment⁶</u>	<u>Period of Water Level Measurement</u>	<u>Sampled in 1991</u>
G35DB	93.9	DPB	66	38	28	H	PT/DL	4/25-5/30	Y
G35S	93.9	DR	23	81	71	D	ET	4/25-5/30	Y
G36D	92.2	SHB	51	51	41	H	PT/DL	4/15-7/9	Y
G36DB	92.0	DPB	82	20	10	H	PT/DL	4/15-7/9	Y
G36DB2	91.8	DPB	217	-115	-125	H	PT/DL	4/15-7/9	Y
G36S	92.8	DR	38	65	55	D	ET	4/25-5/30	Y
NEP-A	61.3	BR	600	1	-539	L	CR	4/15-7/9	N
NEP-B	60.3	BR	600	18	-540	L	CR	4/15-7/9	N
NEP-1	61.0	BR	358	16	-297	5	ET	4/25-5/30	N
NEP-2	60.0	BR	500	33	-440	5	ET	4/25-5/30	N
NEP-3	60.7	BR	940	15	-879	5	ET	4/25-5/30	N
NEP-101	60.3	DR	12	56	48	5	ET	4/25-5/30	N
NEP-101B	60.2	BR	30	35	30	5	ET	4/25-5/30	N
NEP-102	62.1	DR	17	52	45	5	ET	4/25-5/30	N
NEP-102B	62.1	BR	46	21	16	5	ET	4/25-5/30	N
NEP-103	59.1	DR	12	54	48	L	PT/DL	4/15-7/9	N
NEP-103B	59.0	BR	27	39	32	5	ET	4/25-5/30	N
NEP-104	59.9	DR	18	49	42	5	ET	4/25-5/30	N
NEP-104B	59.9	BR	42	25	18	5	ET	4/25-5/30	N

TABLE 2.2-5 (continued)

<u>Well ID</u>	<u>Ground Elev.</u>	<u>Geologic Unit Screened¹</u>	<u>Well Depth²</u>	<u>TOS Elev.³</u>	<u>BOS Elev.⁴</u>	<u>Measurement Frequency⁵</u>	<u>Type of Monitoring Equipment⁶</u>	<u>Period of Water Level Measurement</u>	<u>Sampled in 1991</u>
NEP-105B	59.8	BR	22	45	38	5	ET	4/25-5/30	N
NEP-106B	58.2	BR	48	17	10	5	ET	4/25-5/30	N
NEP-107B	60.8	BR	51	17	10	5	ET	4/25-5/30	N
NEP-108A	61.1	DR	30	41	31	5	ET	4/25-5/30	N
NEP-108B	61.0	BR	55	11	6	5	ET	4/25-5/30	N
NEP-109	59.3	DR	17	52	42	5	ET	4/25-5/30	N
NEP-110B	59.7	BR	100	51	-40	5	ET	4/25-5/30	N
EPA-1	58.0	DR	30	38	28	5	ET	4/25-5/30	N
EPA-2	60.4	DR	30	41	31	5	ET	4/25-5/30	N
EPA-3	60.9	DR	26	45	35	5	ET	4/25-5/30	N
RW-1	96.9	DR/SHB	32	85	65	D	ET	4/25-5/30	Y
RW-2	94.4	DR/SHB	33	81	61	D	ET	4/25-5/30	Y
RW-3	94.2	DR/SHB	32	82	62	D	ET	4/25-5/30	Y
RW-4 (G33D)	94.2	SHB	73	72	21	D	ET	4/25-5/30	Y
RW-5 (G33S)	94.3	DR	22	77	72	D	ET	4/25-5/30	Y
RW-6	94.2	DR/SHB	32	82	62	D	ET	4/25-5/30	Y
RW-7	92.5	DR/SHB	48	64	44	D	ET	4/25-5/30	Y
RW-8	91.9	DR/SHB	48	64	44	D	ET	4/25-5/30	Y

TABLE 2.2-5 (continued)

<u>Well ID</u>	<u>Ground Elev.</u>	<u>Geologic Unit Screened</u> ¹	<u>Well Depth</u> ²	<u>TOS Elev.</u> ³	<u>BOS Elev.</u> ⁴	<u>Measurement Frequency</u> ⁵	<u>Type of Monitoring Equipment</u> ⁶	<u>Period of Water Level Measurement</u>	<u>Sampled in 1991</u>
RW-9	91.3	DR/SHB	45	66	46	D	ET	4/25-5/30	Y
RW-10	91.1	DR/SHB	45	66	46	D	ET	4/25-5/30	Y

Notes:

- Under Geologic Unit Screened; "DR" is unconsolidated glacial drift, "SHB" is shallow bedrock, "DPB" is deep bedrock, DR/SHB is well screened in the glacial drift and shallow bedrock, "BR" indicates a bedrock well of unknown depth.
- All elevations and depths are in feet and all elevation data is approximate.
- TOS Elev. = Top of Screen Elevation in feet.
- BOS Elev. = Bottom of Screen Elevation in feet.
- Under Measurement Frequency; "5" indicates five measurements within the interval described in the text, "D" indicates daily, "H" indicates every 15 minutes, "H/D" indicates hourly during the first twelve hours of the 30 day pumping test then daily, D/3 applies to a specific version of the Solinst Multilevel Sampling System which will be measured on a daily basis for the first five days of the 30 day pumping test followed by 3 measurements one week apart starting one week after the five daily measurements, "L" indicates every 15 minutes on those wells monitoring cyclic fluctuations.
- Under Type of Monitoring Equipment; "ET" is an electric tape, "PT/DL" is a pressure transducer and data logger, "AL" is similar to an air line as described in the Quality Assurance/Quality Control Plan under Solinst Multilevel Sampling System, "PT" is a pressure transducer also described in the Quality Assurance Plan.

"CR" Continuous Stevens Recorder.

water level monitoring are listed on Table 2.2-5. Locations of the pilot test water level monitoring wells are included on Plate 1. The water-level data for each of the wells measured have been plotted as a hydrograph and are included in Appendix B. Water-level potentiometric maps of the unconsolidated deposits and upper bedrock under pre-pumping conditions are shown on Figures 2.2-1 and 2.2-2. Ground water, in general, flows westerly and southwesterly from higher ground-water elevations in the north and northeast to lower ground-water elevations in the river valley.

Continuous monitoring was conducted in several monitoring wells to observe possible water-level fluctuations from other factors such as earth tides, precipitation, or other pumping wells. Observations regarding this monitoring are discussed in Section 3.4 of this report. Data-logger data are included in Appendix C.

Barometric Pressure and Precipitation Data

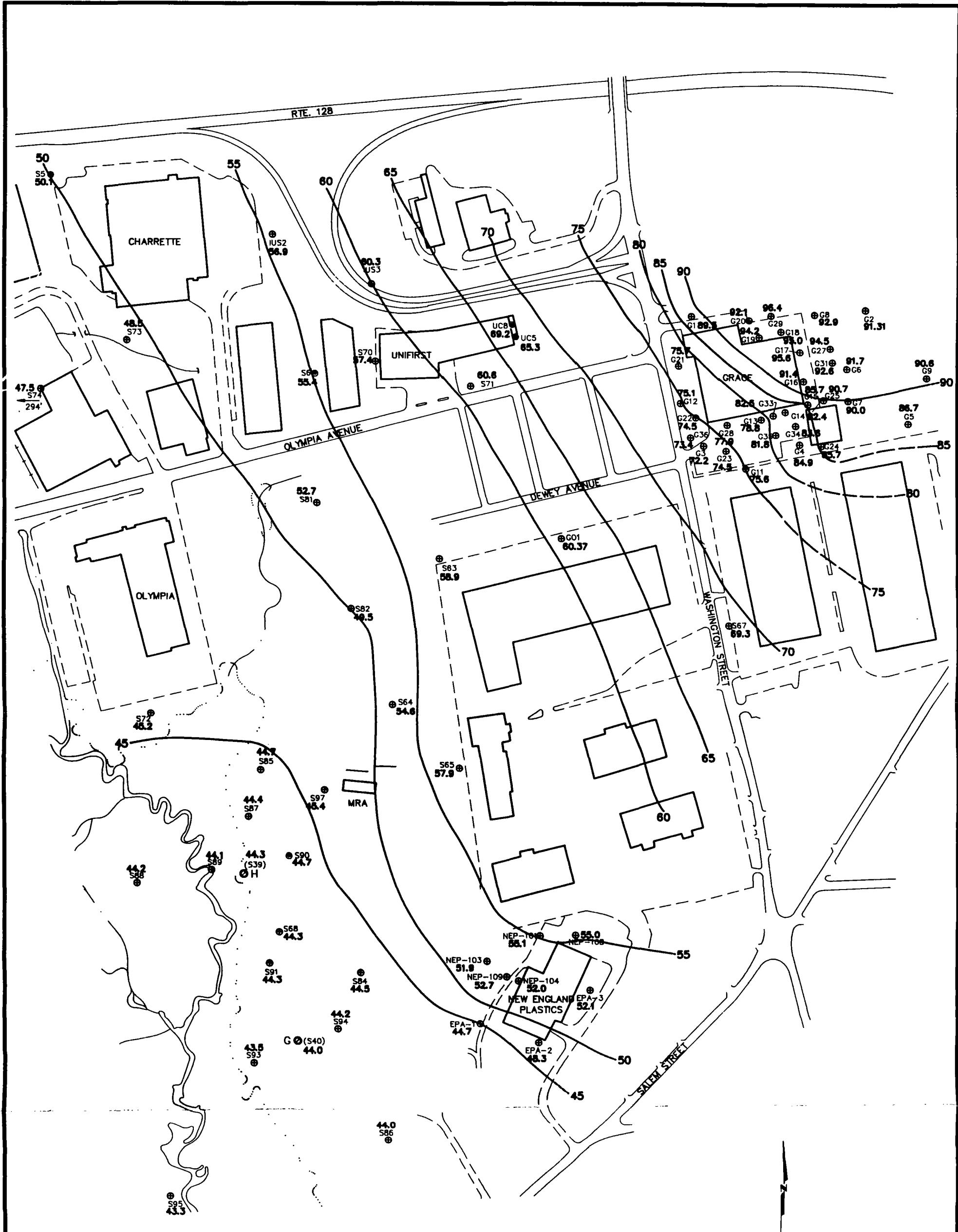
Barometric pressure and precipitation data were collected on the Grace property during the pilot test. A chart recording barograph was used to record barometric pressure from April 15 to July 9, 1991. The barograph was calibrated prior to installation at the Grace property with the barograph at Logan International Airport, Boston, Massachusetts. Precipitation data were collected from April 25 to May 31, 1991.

The barometric pressure and precipitation data recorded during the test (April 25 to May 31, 1991) are shown on Figures 2.2-3 and 2.2-4. The precipitation data reported by the National Weather Service for Reading, Massachusetts, are shown on Figure 2.2-5. Daily precipitation recorded at the Grace property differs by less than 0.1 inches of the precipitation recorded at the Reading station. The precipitation recorded at the Grace station reflects precipitation which occurred during the previous 24 hours.

The effect of precipitation on water level fluctuations can be seen on several monitoring well hydrographs. Wells G7S and G7D (Figure 2.2-6), for example, are located in an unpaved area to the east side of the Grace property site and approximately 100 feet from the precipitation gauge on the Grace property. Water levels in these wells were not noticeably affected by pumping at the UniFirst or Grace properties, but show water level fluctuations in response to precipitation.

2.2.2 UniFirst

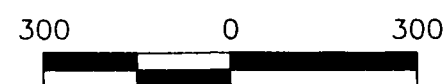
Prior to the 30-day pilot test the following tasks were completed on the UniFirst property in the specified order: well-integrity testing of 43 monitoring points; surveying; drilling one bedrock



EXPLANATION

- 01 @ 0.5 MONITORING WELL SCREENED IN UNCONSOLIDATED DEPOSITS AND
WATER LEVEL ELEVATION ON 4/25/91 ROUNDED TO THE TENTH
- 2 ABANDONED WATER WELL SCREENED IN UNCONSOLIDATED DEPOSITS
- 3 MONITORING WELL SCREENED IN BEDROCK AND UNCONSOLIDATED DEPOSITS
- 70 — LINE OF EQUAL WATER LEVEL ELEVATION, FIVE FOOT CONTOUR INTERVAL

NOTE: ALL WATER LEVEL ELEVATIONS ARE FROM S (SHALLOW) WELLS



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SCALE IN FEET

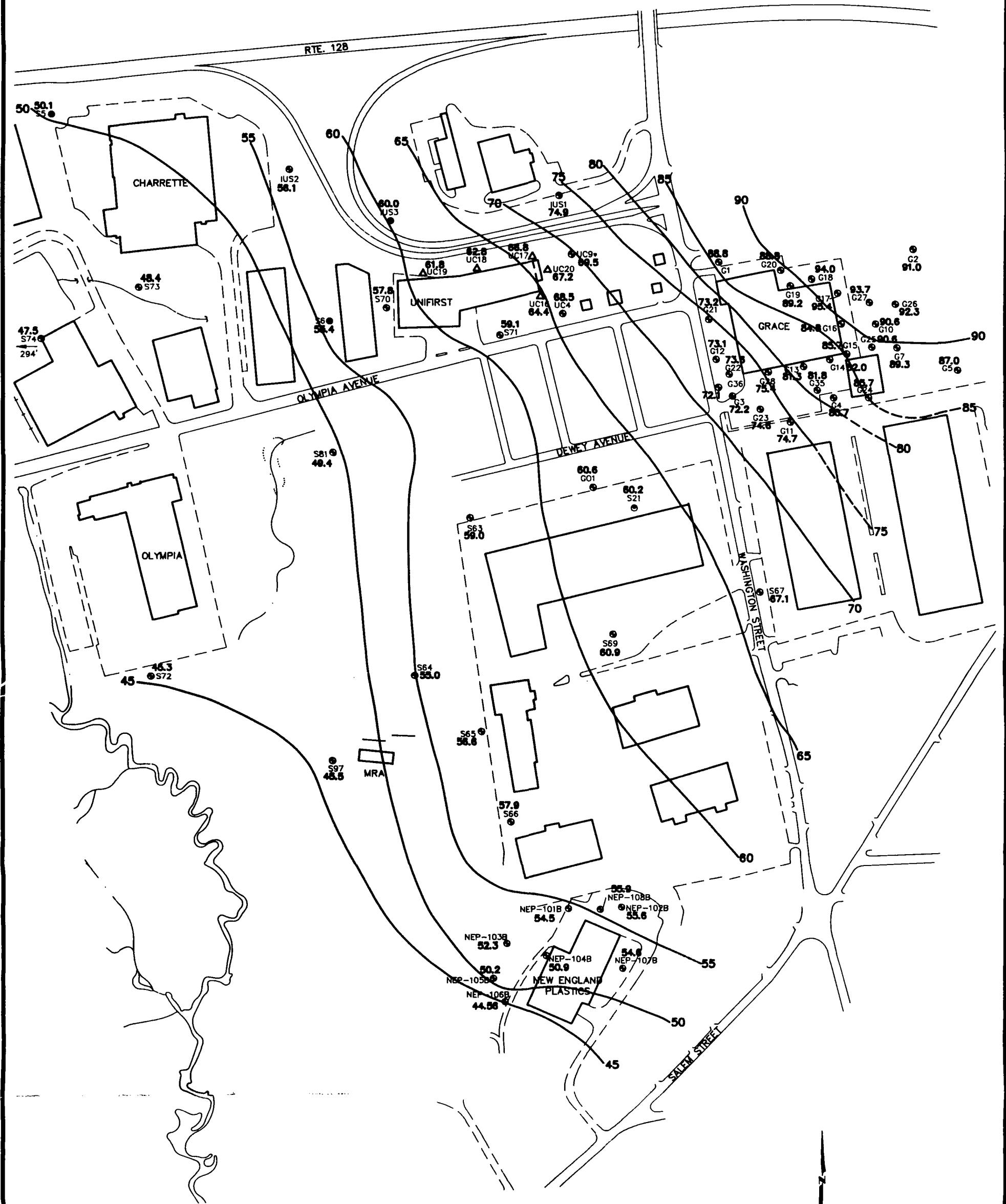
**Remedial Design of
the Northeast Quadrant
Wells G & H Site
Woburn, MA**

FIGURE 2.2-1

**Estimated Pre-Pumping Potentiometric
Surface of the Unconsolidated Deposits**

Prepared by: ENSR Consulting and Engineering

MAP SOURCE: 1966 TOPOGRAPHIC MAP FOR PLANNING BOARD, CITY OF WOBURN, MASSACHUSETTS, LOCKWOOD, KESSLER & BARTLETT, INC., INCLUDING THE MODIFICATIONS MADE BY THE U.S. GEOLOGICAL SURVEY AND CONTAINED IN A 1987 U.S. GEOLOGICAL SURVEY WATER RESOURCES INVESTIGATIONS REPORT 87-4100 TITLED "AREA OF INFLUENCE AND ZONE OF CONTRIBUTION TO SUPERFUND-SITE WELLS G AND H, WOBURN, MASSACHUSETTS".



EXPLANATION

- G1 @ 88.8 MONITORING WELL SCREENED IN SHALLOW BEDROCK AND WATER LEVEL ELEVATION ON 4/25/91 ROUNDED TO THE TENTH
- MONITORING WELL SCREENED IN BEDROCK AND UNCONSOLIDATED DEPOSITS
- 70 — LINE OF EQUAL WATER LEVEL ELEVATION, FIVE FOOT CONTOUR INTERVAL
- Δ 8-INCH WELL OPEN IN ROCK; UC22 IS AN 8-INCH WELL
- * ASTERISK INDICATES MULTI-PORT WELLS (e.g. UC10*)

300 0 300

DRAFT

SCALE IN FEET

Remedial Design of
the Northeast Quadrant
Wells G & H Site
Woburn, MA

FIGURE 2.2-2

Estimated Pre-Pumping Potentiometric
Surface of the Shallow Bedrock

Prepared by: ENSR Consulting and Engineering

MAP SOURCE: 1966 TOPOGRAPHIC MAP FOR PLANNING BOARD, CITY OF WOBURN, MASSACHUSETTS, LOCKWOOD, KESSLER & BARTLETT, INC., INCLUDING THE MODIFICATIONS MADE BY THE U.S. GEOLOGICAL SURVEY AND CONTAINED IN A 1987 U.S. GEOLOGICAL SURVEY WATER RESOURCES INVESTIGATIONS REPORT 87-4100 TITLED "AREA OF INFLUENCE AND ZONE OF CONTRIBUTION TO SUPERFUND-SITE WELLS G AND H, WOBURN, MASSACHUSETTS".

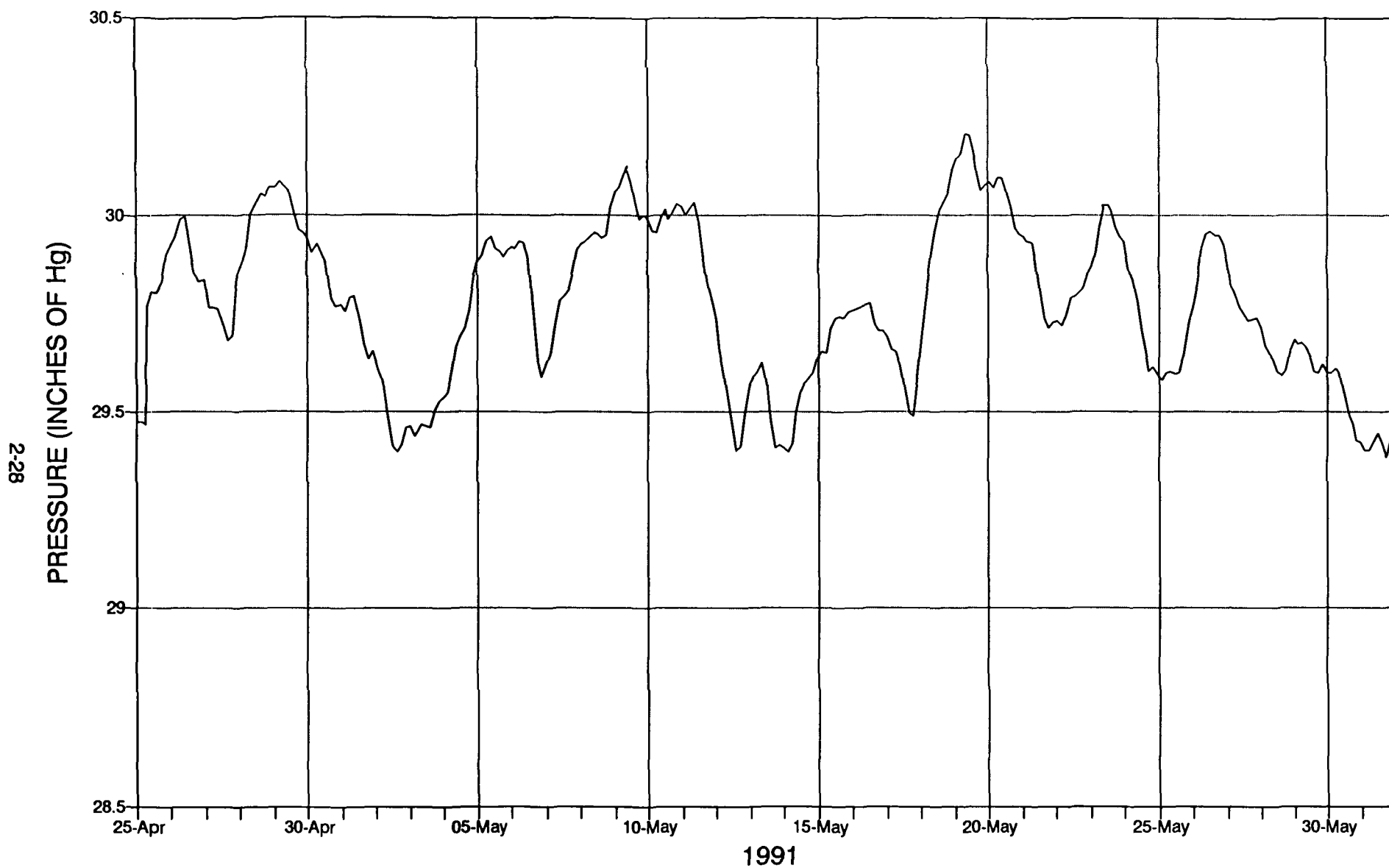


FIGURE 2.2-3

Barometric Pressure Measured in the Northeast Quadrant, April 25 to June 1, 1991

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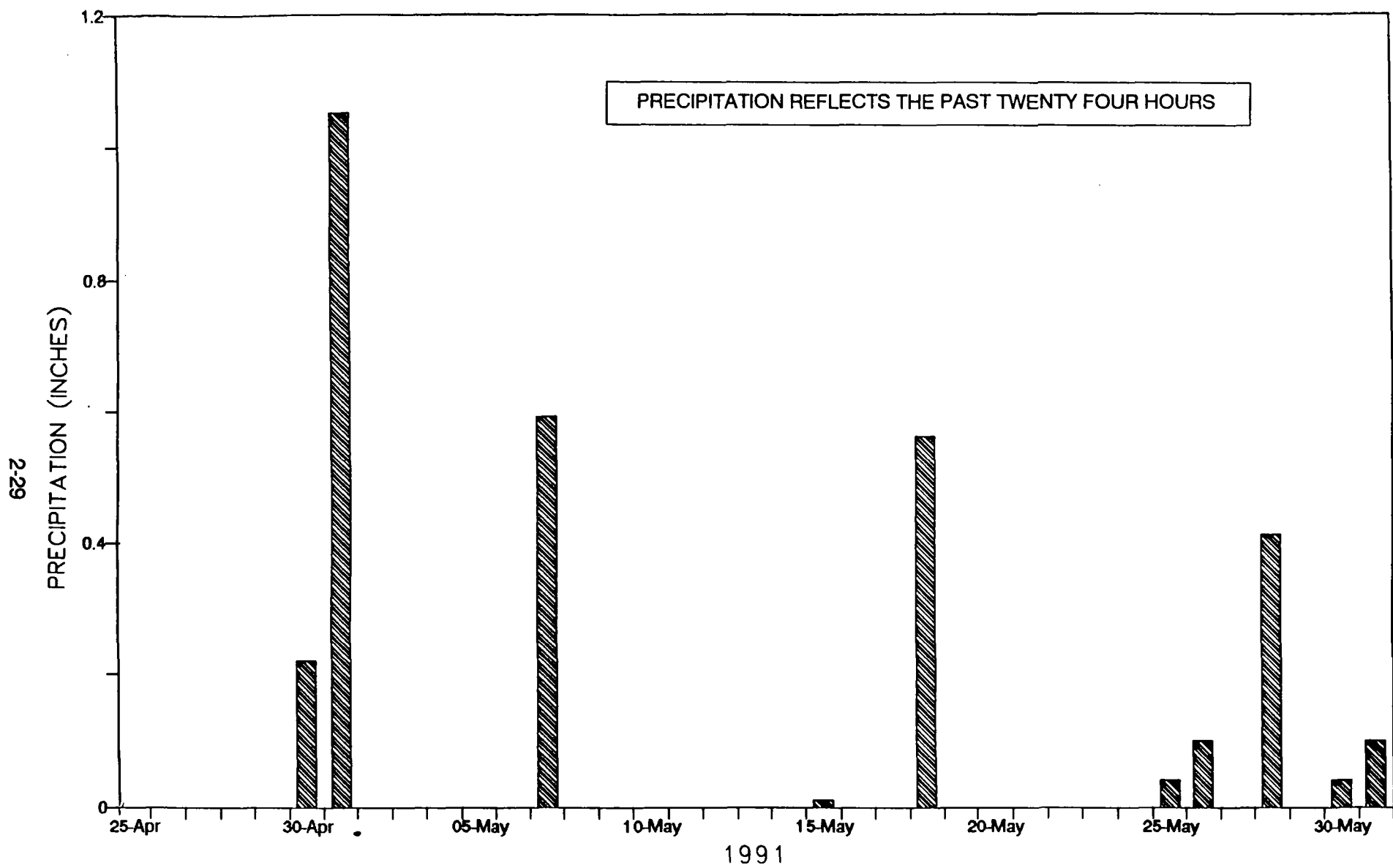


FIGURE 2.2-4

Precipitation Measured in the Northeast Quadrant, April 25 to June 1, 1991

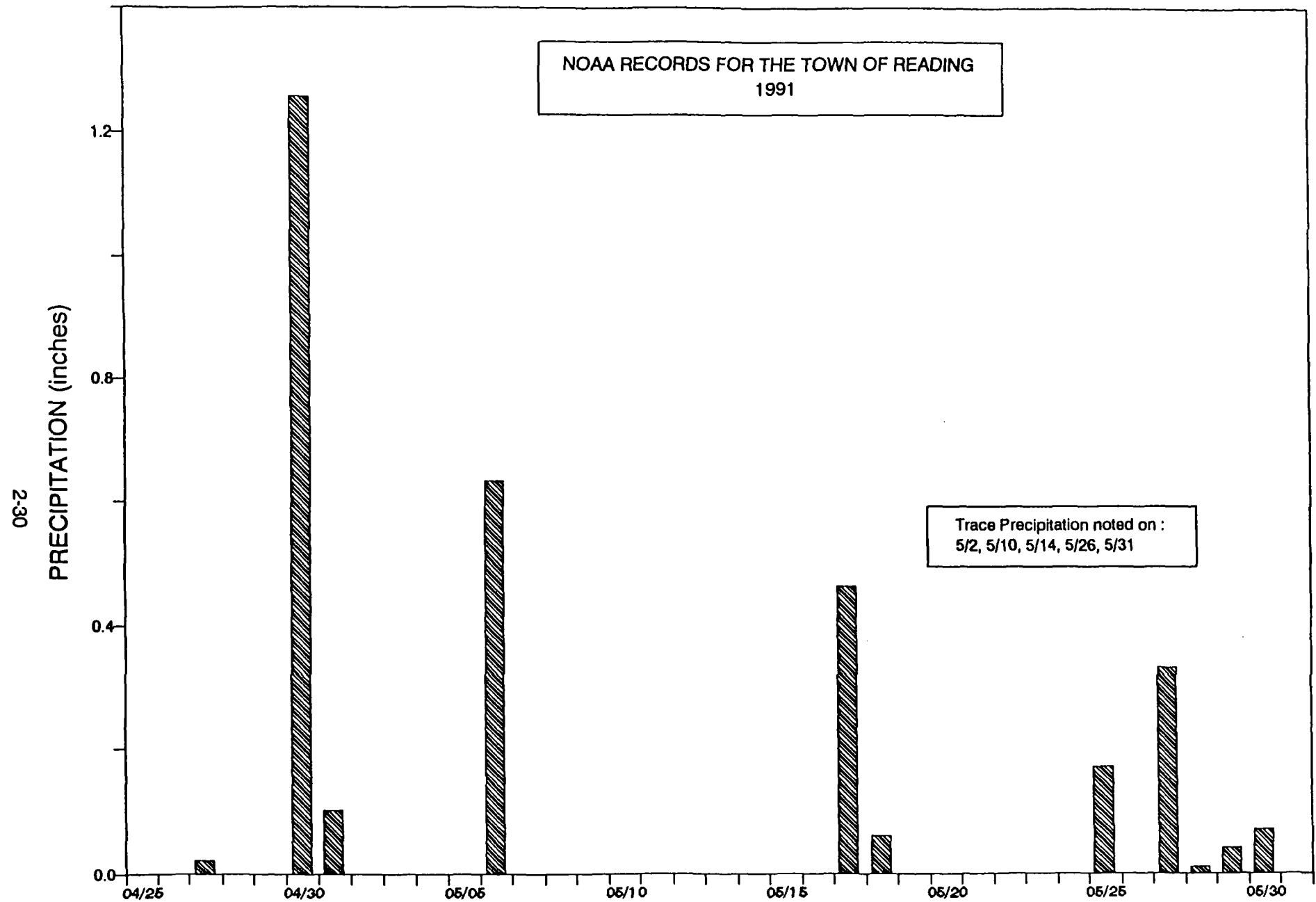


FIGURE 2.2-5

Precipitation Measured at Reading, Massachusetts, April 25 to June 1, 1991

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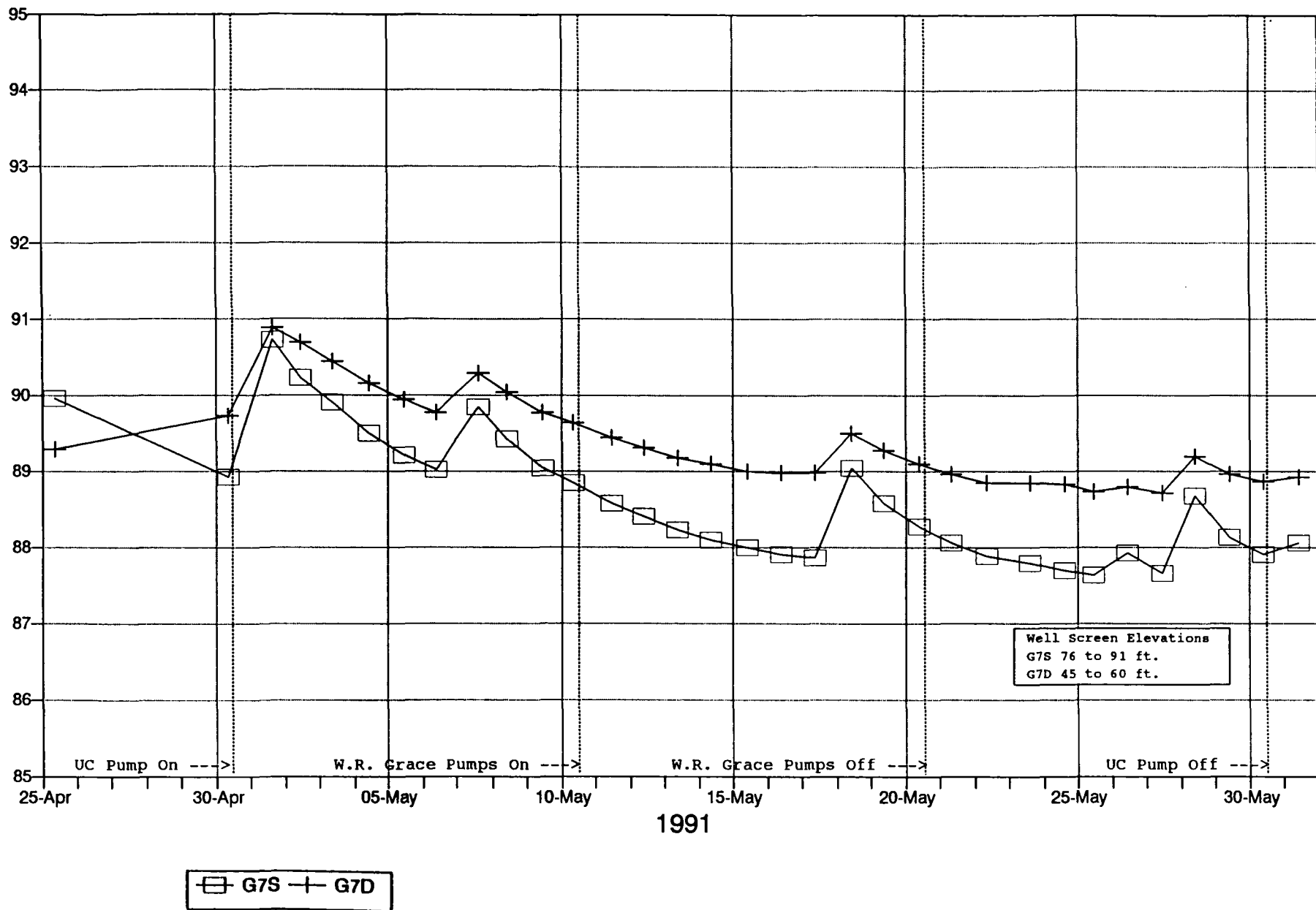


FIGURE 2.2-6

borehole; geophysical surveys in two boreholes; installation of one multilevel monitoring well and two conventional monitoring wells; ground-water-quality sampling and analysis; a four-hour pumping test of UC22 and; ground-water-elevation measurements.

Monitoring Well Installations

One borehole at location UC23 (see Plate 1) was drilled on the UniFirst property for the purpose of installing a multilevel monitoring well. The borehole was drilled with an air rotary technique to a total depth of 400 feet. Approximate water production from the borehole was recorded from visual estimations while drilling along with head space monitoring of ground-water samples for VOC concentrations. The results of the monitoring and boring log are presented in Appendix D.

Monitoring wells were installed at two locations, UC15 and UC23. The six-inch borehole at the UC15 location contains two monitoring wells of two-inch stainless steel construction screened from 78 to 88 feet and 270 to 280 feet below ground surface. The six-inch borehole at the UC23 location contains a direct measurement multilevel Solinst well of five monitoring ports separated by expandable packers. The Solinst multilevel monitoring well system is described in the QA/QC plan. The five UC23 monitoring points are located at approximately 399, 384, 303, 265, and 242 feet below ground surface. Monitoring well construction details are presented in Appendix D.

Well Survey

All monitoring well locations were surveyed as described in Section 2.2-1 and in the Work Plan. The results of this survey are presented in Appendix A.

Well Integrity Testing

All of the monitoring locations on the UniFirst property were well integrity tested except UC22. These monitoring points are listed below with an asterisk beside those points determined to be inoperable from the integrity tests and therefore were not used for the purposes of this pilot test.

UC4	UC7A-4	UC10-3	UC23-1
UC5	UC7A-5	UC10-4	UC23-2
UC6	UC8	UC10-5	UC23-3
UC7-1	*UC9-1	UC10-6	UC23-4
UC7-2	UC9-2	UC15S	UC23-5
UC7-3	*UC9-3	UC15D	S70S
UC7-4	UC9-4	UC16	S70M
UC7-5	*UC9-5	UC17	S70D

UC7A-1	UC9-6	UC18	S71S
UC7A-2	UC10-1	UC19	S71D
UC7A-3	UC10-2	UC20	

Well UC22 was not integrity tested using the same methods as other wells because access to the well was blocked by the pump installation. Well UC22 was considered integrity tested following the four-hour pumping test described below. All conventional monitoring wells were well integrity tested as described in the Work Plan. All Solinst multilevel monitoring installations were tested by evacuating the monitoring point tubes and recording the water-level recovery. The procedure for the Solinst well operation is described in the QA/QC plan. The results of the UniFirst well integrity tests are provided in Appendix A as field data collection forms.

Borehole Geophysics

Borehole geophysical surveys were performed in UC15 and UC23 before installing monitoring wells. The purpose of the borehole geophysical logging was to identify permeable fracture zones for monitoring locations. Seven geophysical methods were used in each borehole. The methods included temperature logging before and after 10 percent of the borehole water volume was removed, caliper, self-potential, single point resistivity, natural gamma, density and neutron logging. A summary of the geophysical results is presented in Appendix E. Geophysical logs are available upon request.

Ground-Water Sampling

Ground-water samples were collected from 13 monitoring points on the UniFirst property, which include UC5, UC6, UC7-1, UC7-2, UC7-3, UC18, UC23-1, UC23-1, UC23-3, UC23-4, UC23-5, S71S and S71D. These results are presented in Appendix F and discussed in greater detail in Section 2.3.

Ground-Water Pumping Test

A four-hour pumping test of well UC22 was performed at 50 gallons per minute to further confirm that the proposed pumping rate could be sustained. In addition, water levels were measured in monitoring wells near UC22 for preliminary indications of pumping effects. Straight line projections of time-drawdown curves generated from the four-hour test and detailed evaluations of the 1988 72-hour testing of well UC22 were used to estimate a likely and a reasonable worst-case 30-day drawdown.

2.2.3 Grace

Monitoring and Recovery Well Installation

Three additional monitoring well clusters, G34, G35, and G36, were installed on the Grace property between August 22 and October 3, 1990. The well clusters were located near the recovery wells to monitor water level response to pumping during the pilot test and to obtain additional water quality information. Well screens were placed at discrete locations within the bedrock or unconsolidated deposits. In-situ water pressure tests were conducted in the bedrock boreholes to aid in the placement of bedrock well screens. Well locations are shown on Figure 2.2-7 and well construction details are included on Table 2.2-5. Boring logs and monitoring well details are included in Appendix D.

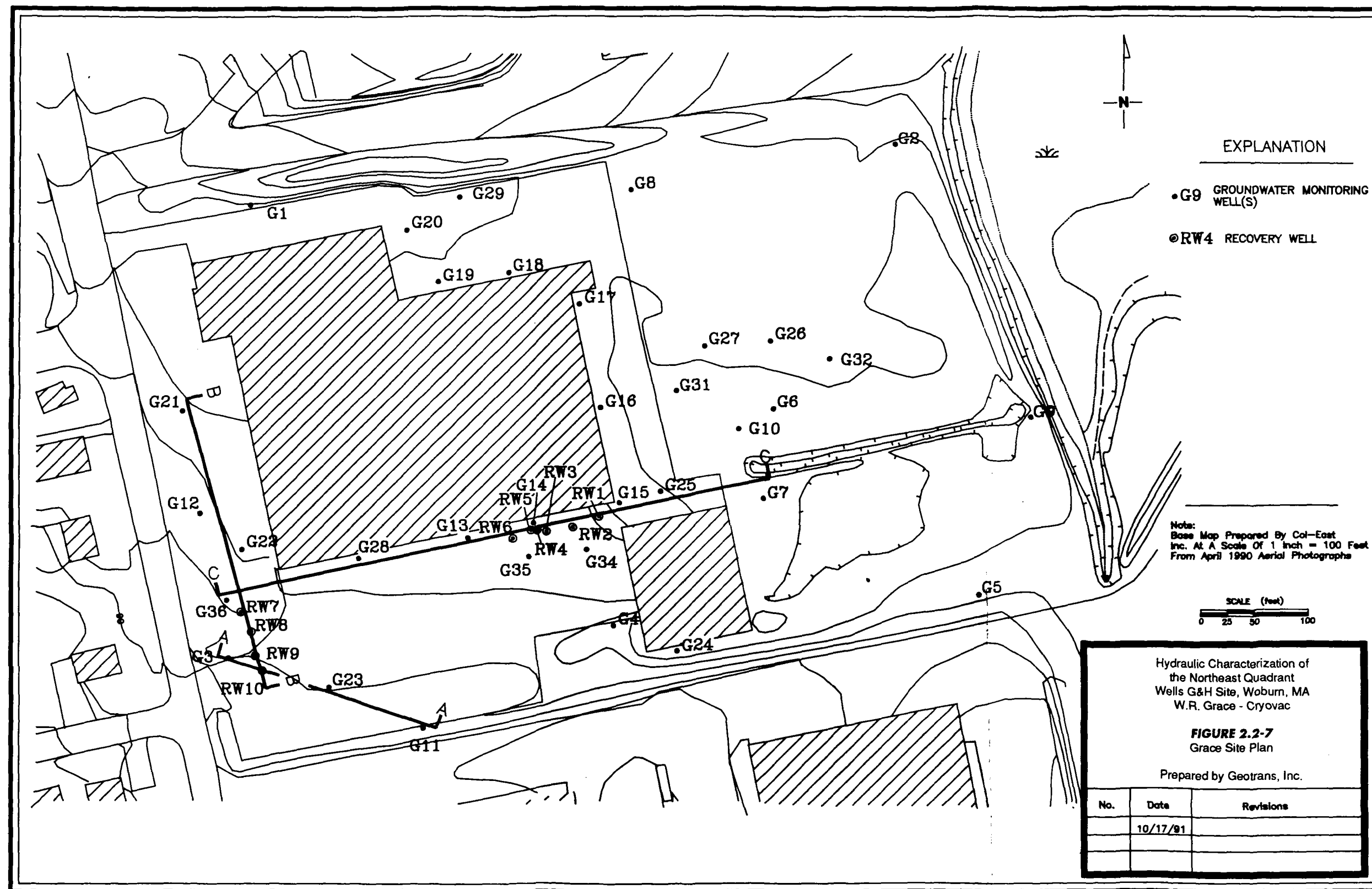
Eight four-inch diameter recovery wells were installed on the Grace property using the dual-air rotary drilling method. Well locations are shown on Figure 2.2-7. Four recovery wells were placed along the southeast side of the main building, for a total of six recovery wells at that location, and four recovery wells were placed along the downgradient property boundary parallel to Washington Street. A 20-foot stainless-steel well screen with 0.010-inch slot openings was placed in each well. The screened interval in each well extended from ten feet below to ten feet above the bedrock surface. Drilling logs and recovery well details are included in Appendix D.

Water from the Woburn municipal water supply system was used in drilling and pressure testing the monitoring wells. A sample of the water was collected for VOC analysis from the hose bib where the drillers obtained the water. The sample contained the following trihalomethane compounds, typical of chlorinated drinking water.

<u>Compound</u>	<u>Concentration ($\mu\text{g/l}$)</u>
Bromochloromethane	5.4
Chloroform	2.7
Dibromochloromethane	0.73

The complete laboratory report is included in Appendix G.

None of these compounds were detected in samples collected from the new monitoring wells or the recovery wells.



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Disposal of Drill Cuttings and Water

The soil and rock cuttings from the drilling of the monitoring wells and recovery wells were contained in a lined and covered roll-off dumpster. A composite sample of the cuttings was collected and analyzed for VOC (EPA Method 8240). No VOC were detected above the soil action levels published in the Record of Decision (EPA, 1989). With the consent of EPA, the soil and rock cuttings were considered as non-hazardous and were subsequently spread on the ground at the edge of the paved area behind the Grace main building.

Water from recovery well drilling, well development, and short-term pumping tests was transferred to two tanker trucks. A water sample was collected from each truck and analyzed for VOC. Total VOC reported in the samples were 316 and 1,130 $\mu\text{g/l}$ respectively. The contents of the trucks were disposed of at the Environmental Waste Resources, Inc. treatment facility in Waterbury, Connecticut, a licensed waste disposal facility. Laboratory analysis results for cuttings and ground water are included in Appendix D.

Ground-Water Sampling

Ground-water samples were collected on the Grace property from the newly installed monitoring and recovery wells and from existing monitoring wells on the downgradient property boundary. The wells which were sampled are listed on Table 2.2-6. The samples were analyzed for volatile organic and semivolatile compounds. The new wells were sampled to determine baseline ground-water quality at the new monitoring locations. The sample results from the Grace downgradient property boundary wells were used to calculate contaminant mass flux from the Grace property under non-pumping conditions.

2.3 Geochemistry and Contaminant Characterization

2.3.1 UniFirst

2.3.1.1 History

At the UniFirst property, there is a dense non-aqueous phase liquid (DNAPL) source in the bedrock as well as aqueous or dissolved-phase contamination. It is not known how this DNAPL got there, or how much is present. Since it was discovered when a shallow bedrock well (UC8) was drilled through an old dry well which formerly served but now is beneath a loading dock, the DNAPL is hypothesized to have entered the bedrock via the former dry well. The bottom of the dry well was within approximately two feet of the bedrock surface before excavation. Given the location of the dry well, there was a limited thickness and area of unconsolidated deposits

TABLE 2.2-6

Grace Monitoring and Recovery Wells
Sampled and Analyzed
for Volatile and Semi-Volatile Compounds

G1DB2	G35S
G1DB3	G35D
G3S	G35DB
G3DB	G36S
G3DB2	G36D
G11S	G36DB
G11D	RW1
G12S	RW2
G12D	RW6
G21S	RW7
G21D	RW8
G22S	RW9
G22D	RW10
G23S	
G23D	
G33S	
G33D	
G34S	
G34D	

(Note: Other Grace wells, which were also sampled and analyzed for the parameters listed in Table 2.2-2, are included on Table 2.2-1)

available for the DNAPL to pass through and adhere to soil particles. The DNAPL is hypothesized to have continued to move through the bedrock fractures adhering to rock and settling out in small dead-end fractures yielding dissolved constituents to flowing ground water.

Historic water quality analytical results from wells screened in unconsolidated deposits on the UniFirst property detected VOC contamination at levels between non detection and 1.9 milligrams per liter. The VOC detected at the highest concentrations in the ground water on the site is tetrachloroethene, which was detected at levels up to 17 milligrams per liter in the deep bedrock beneath the site. Monitoring well UC8 is the only point on the UniFirst site where DNAPL has been found.

2.3.1.2 Unconsolidated Deposits: VOC and Metals

Of the three monitoring wells on the UniFirst property screened in unconsolidated deposits (S71S, UC6 and S70S), ground water was sampled from two locations in the 1991 sampling round and analyzed for VOC and metals, S71S and UC6. The sampling analysis plan and procedures are contained in the remedial design work plan and QA/QC plan. Tetrachloroethene, trichloroethene and 1,1,1-trichloroethane were detected in the ground-water samples from S71S at 1100, 7 and 21 micrograms per liter, respectively. Tetrachloroethene and trichloroethene were detected in ground-water samples from UC6 at 1700 and 30 micrograms per liter respectively.

The results for VOC, metals, semi-volatiles, pesticides, PCB, radionuclides and other inorganic parameters analyzed from the 1991 sampling round are presented in Appendix F. Table 2.3-1 shows the maximum concentrations of metals detected in all wells in the unconsolidated deposits and bedrock and typical concentrations for ground water in New England.

2.3.1.3 Bedrock: VOC and Metals

Ground water from eleven monitoring points in the bedrock were sampled for the above mentioned parameters on the UniFirst property in the 1991 sampling round which are as follows: UC5, UC7-1, UC7-2, UC7-3, UC18, UC23-1, UC23-2, UC23-3, UC23-4, UC23-5 and S71D. The VOC detected and their respective ranges in concentration in micrograms per liter are as follows:

- | | | |
|---|-----------------------|---------------------------|
| • | tetrachloroethene | 1,300 to 53,000, |
| • | 1,1,1-trichloroethene | not detected (ND) to 480, |
| • | trichloroethene | ND to 340, |
| • | 1,1-dichloroethene | ND to 100, |
| • | 1,1-dichloroethane | ND to 390, |

TABLE 2.3-1

Metals Concentrations for Ground Water on the UniFirst Property
(concentrations in µg/l)

Analyte	Detection Limit (ppb)	Maximum Value (ppb)	Typical Value ** (ppb)
Aluminum	95.6	822	<5.0–1000
Antimony	<3.5	–	–
Arsenic	<1.5	25.8	<1.0–30
Barium	31.3	59	10–500
Beryllium	1.4	–	<10
Cadmium	<4	–	<1.0
Chromium	<11	17	<1.0–5.0
Cobalt	7.9	19	<10
Copper	<23	8J	<1.0–30
Cyanide	10	45.7J	–
Iron	<237	5400	10–10,000
Lead	<6.5	30.2J	<15
Magnesium	5000	17100/18700J	1000–50,000
Manganese	<25	3240	<1.0–1000
Mercury	0.2	–	<1.0
Nickel	10.6	–	<10–50
Potassium	1120	5140/5540J	1000–10,000
Selenium	<0.9	11.8	<1.0–10
Silver	<30	–	<5.0
Sodium	5000	390,000	500–120,000
Thallium	0.6	–	–
Vanadium	7.7	29	<1.0–10
Zinc	<173	63J	<10–2000

– No values above detection limit

** Reference: Dragun, J. 1988. The Soil Chemistry of Hazardous Materials, p.79

J – Estimated value below the detection limit.

• 1,2-dichloroethene (total)	ND to 180,
• methylene chloride	ND to 620,
• carbon tetrachloride	ND to 96,
• chlorobenzene	ND to 3,
• toluene	ND to 28,
• chloroform	ND to 6, and
• 2-hexanone	ND to 6.

Table 2.3-1 shows the range of metals concentrations observed in the bedrock wells.

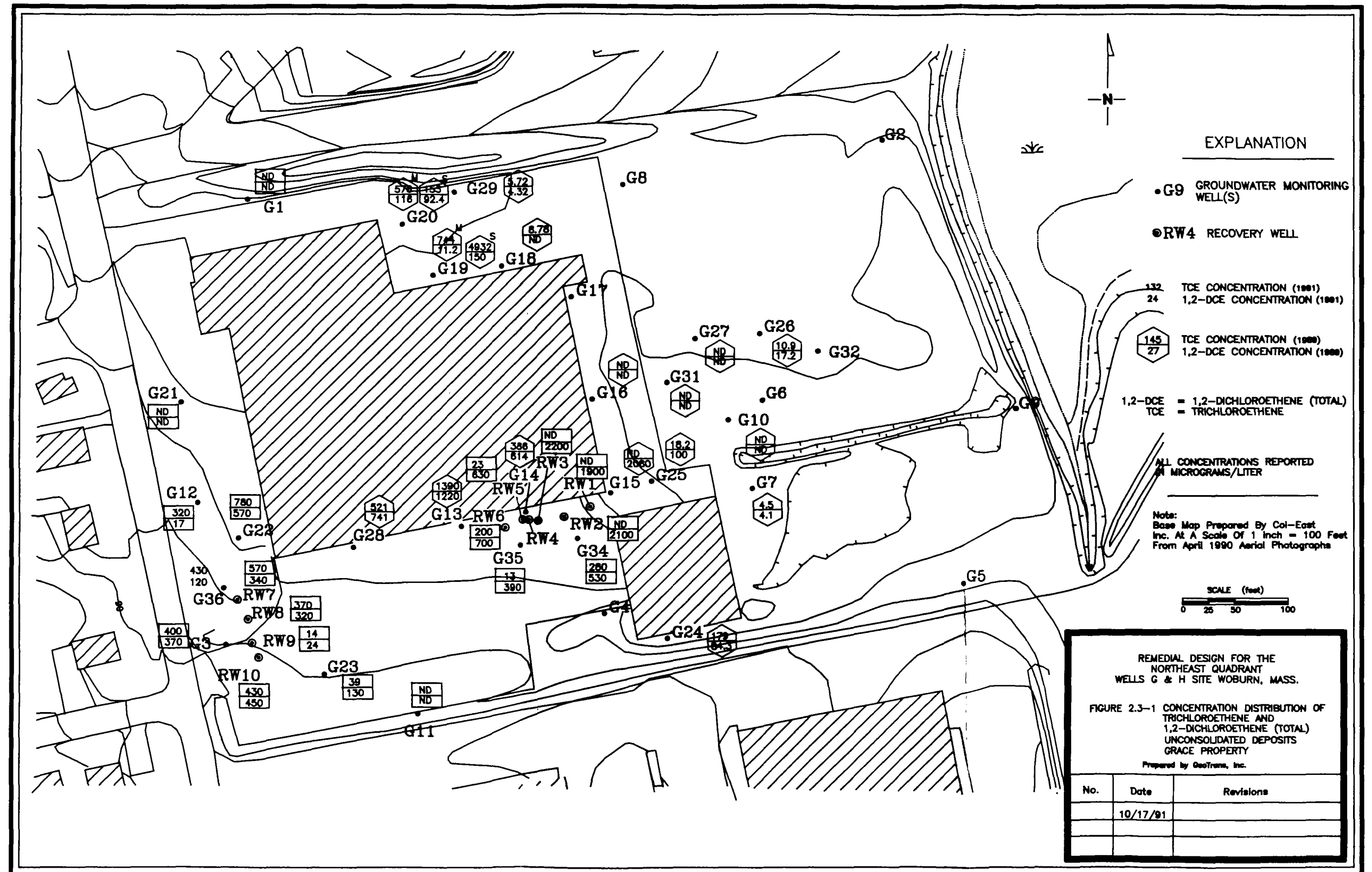
2.3.2 Grace

2.3.2.1 History

Monitoring wells were first installed at the Grace property in 1983. Additional wells were installed in 1984, 1985, 1988, and 1990. Locations of wells on the Grace property are shown on Figure 2.2-1. Since they have been installed, the wells have been sampled for volatile organic compound analysis. Selected wells have also been sampled for analysis of semi-volatile compounds, radionuclides, pesticides/PCB, metals, and other selected inorganic parameters. Past sampling has indicated that the ground water near and hydraulically downgradient of the former south drainage ditch is contaminated primarily with the VOC trichloroethene, 1,2-dichloroethene, vinyl chloride, and with low concentrations of tetrachloroethene. A summary of reported tetrachloroethene, trichloroethene, 1,2-dichloroethene, vinyl chloride and 1,1,1-trichloroethane concentrations for all analyses of Grace on-site monitoring wells is included in Appendix F. The semi-volatile compound bis-2-ethylhexyl-phthalate has occasionally been detected at low concentrations in some wells. Inorganic constituents in the groundwater appear to be within typical ranges of ground water in New England. (Dragun, 1988.) Concentrations of trichloroethene and 1,2 dichloroethene in the ground water near the former south drainage ditch have declined during the period of record and vinyl chloride concentrations do not appear to have changed significantly. Along the downgradient property boundary, the data indicate that concentrations of VOC have decreased since sampling began in 1983.

2.3.2.2 Unconsolidated Deposits: VOC and Metals

The water quality data collected in preparation for the pilot test indicate that the areal extent of VOC contamination in the unconsolidated deposits on the Grace property has not changed since ground-water sampling at Grace began. Figure 2.3-1 shows the distribution of trichloroethene and 1,2 dichloroethene in the unconsolidated deposits on the Grace property.



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High concentrations of these two compounds are present in the area of the former south drainage ditch and near well clusters G19 and G20. The areal distribution of vinyl chloride in the unconsolidated deposits is shown on Figure 2.3-2. Concentrations of trichloroethylene, 1,2 dichloroethylene, and vinyl chloride generally decrease in downgradient directions from these locations. Cross sections showing the vertical distribution of trichloroethene and 1,2-dichloroethene along the downgradient property boundary are shown in Figures 2.3-3, -4, and -5. Cross section locations are shown on Figure 2.2-1.

The concentrations of metals in the ground water at the Grace property all fall within the typical range of concentrations for ground water in New England (Dragun, 1988). Table 2.3-2 lists the range of metals concentrations observed in ground-water samples from the Grace property.

2.3.2.3 Bedrock: VOC and Metals

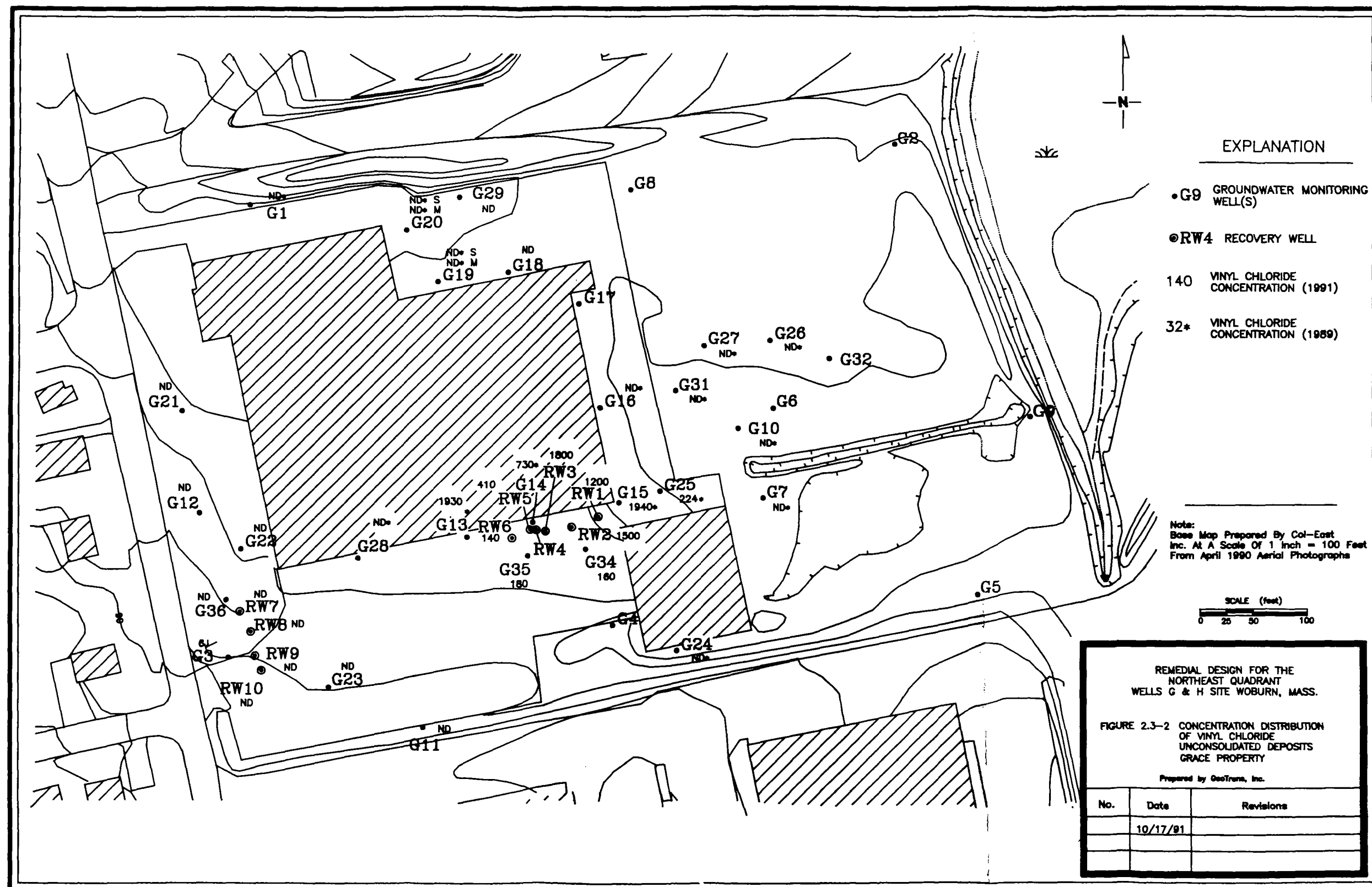
The areal distribution of trichloroethene and 1,2-dichloroethene in the upper bedrock beneath the Grace property is shown on Figure 2.3-6. The areal extent of vinyl chloride in the bedrock is shown on Figure 2.3-7. The areal distribution of contaminants in the bedrock is similar to that in the unconsolidated deposits. Concentrations of metals in ground water from the bedrock beneath the Grace property are typical for ground water in New England (Dragun, 1988). Table 2.3-2 lists the range of metals concentrations observed at the Grace property since ground-water sampling began in 1983.

2.3.2.4 Off-Site Chemical Mass Flux

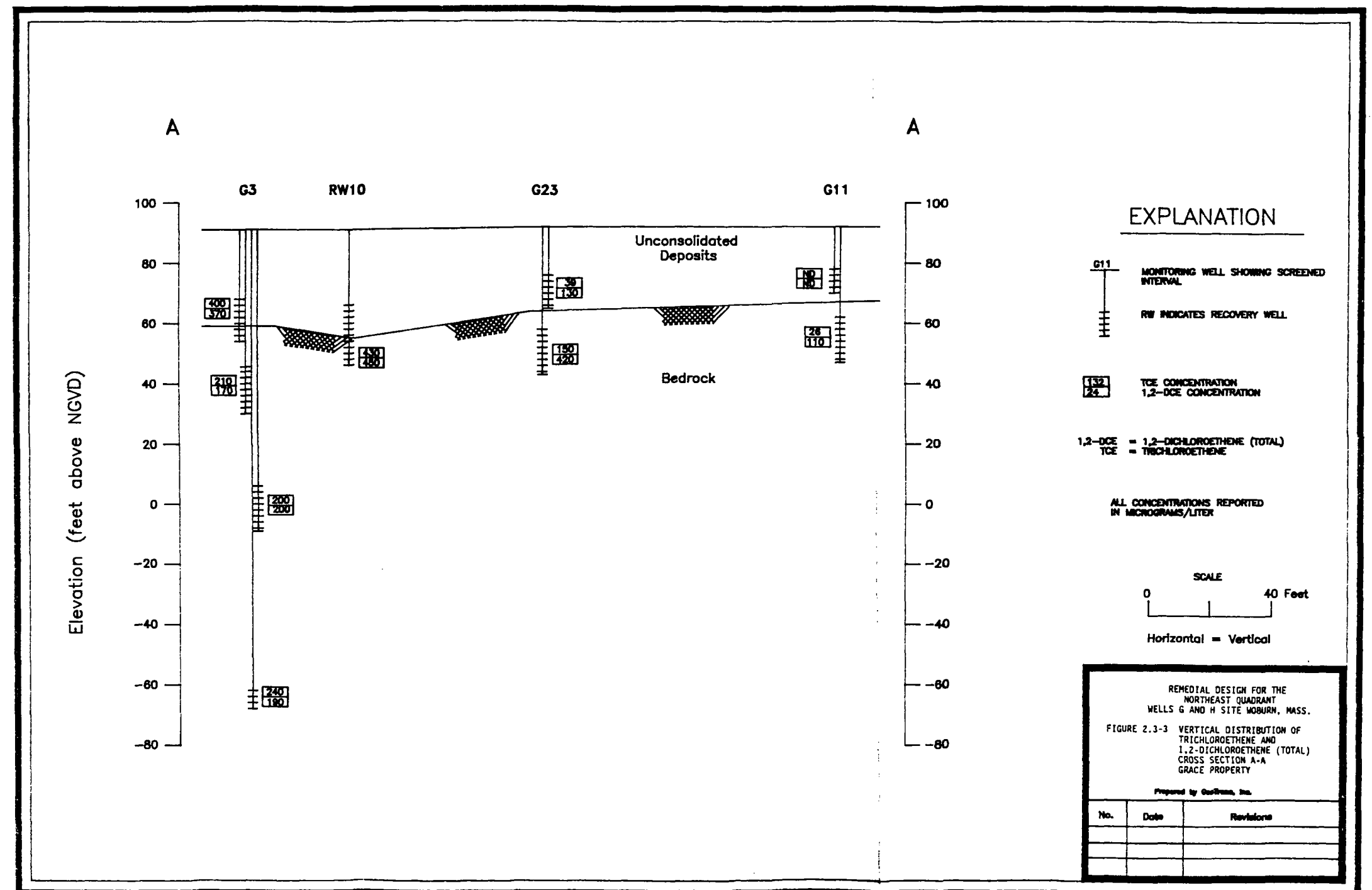
Water quality data collected in February and March 1991 were used to provide revised estimates of off-site chemical mass loading from the Grace property. Previous estimates (GeoTrans, 1987) indicated that approximately 0.04 pounds per day, or about 15.3 pounds per year, of VOC were flowing in the unconsolidated deposits and bedrock from the Grace property toward the center of the Aberjona River Valley. The previous calculations also indicated that trichloroethene and 1,2-dichloroethene comprised about 98 percent of the total off-site chemical flux.

Similar calculations, using the more recent chemical data and a revised flow cross section, indicate that the chemical mass flux from the Grace property has reduced to about 0.03 pounds per day, or 10.7 pounds per year. Trichloroethene and 1,2-dichloroethene still comprise about 98 percent of the total chemical flux.

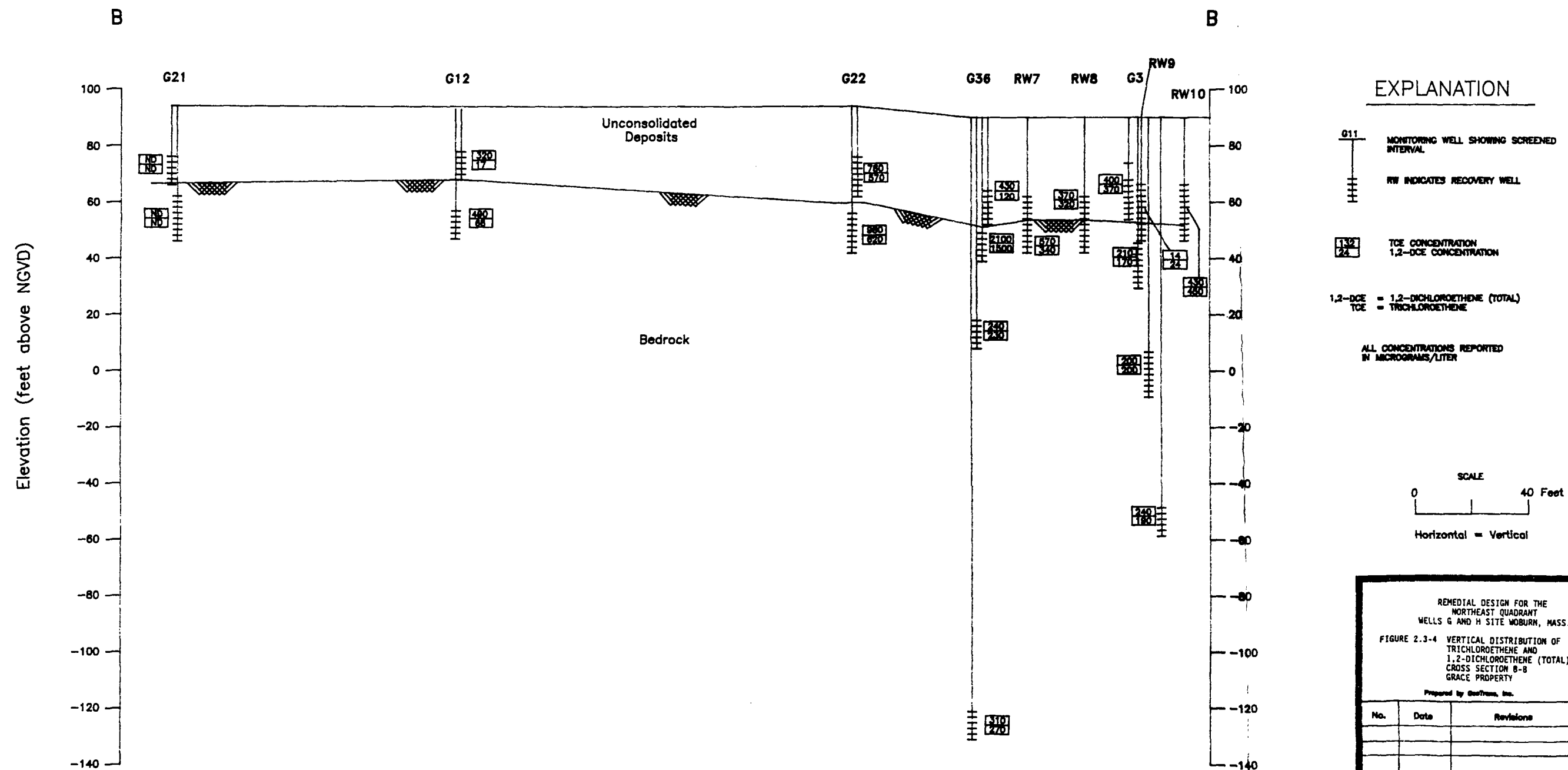
The current chemical mass flux calculations are based on the modified Darcy equation described in a previous GeoTrans report (GeoTrans, 1987, p. 197). Revisions to the flow cross section used in the calculations include a greater depth to the flow section (285 feet compared to 100



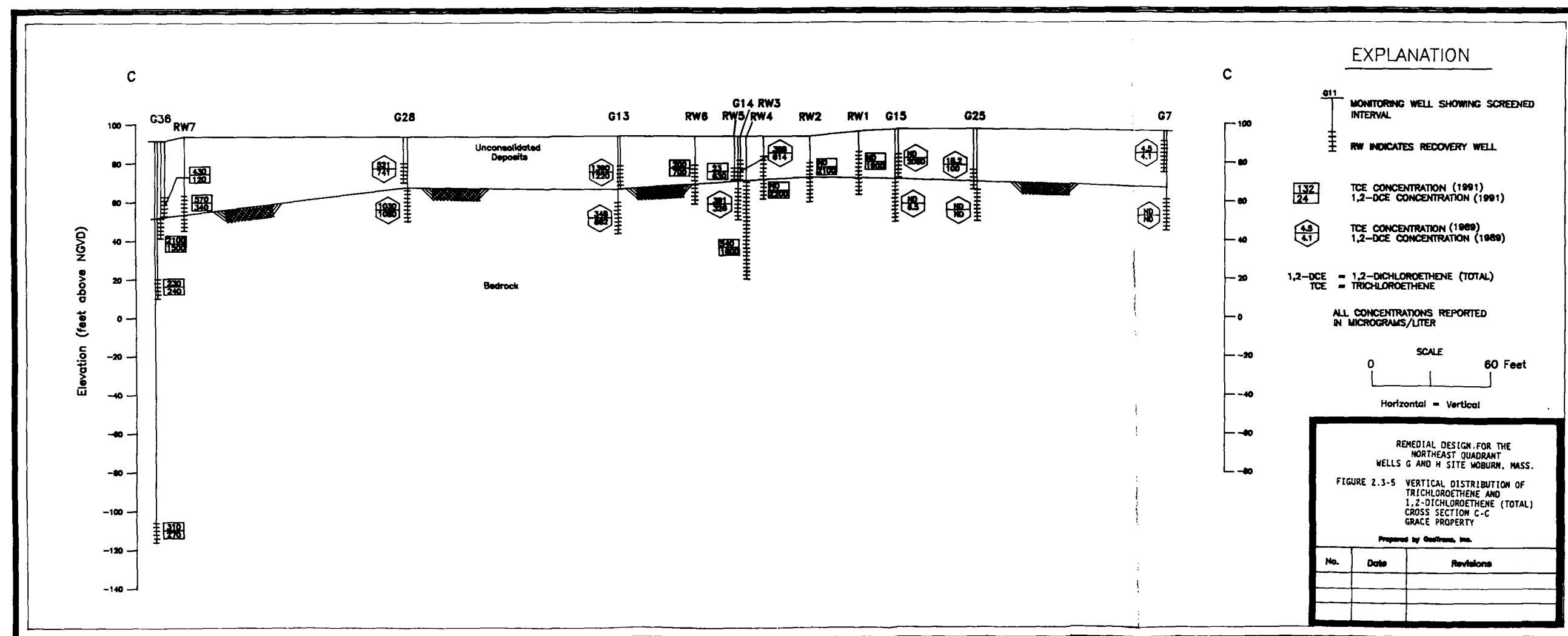
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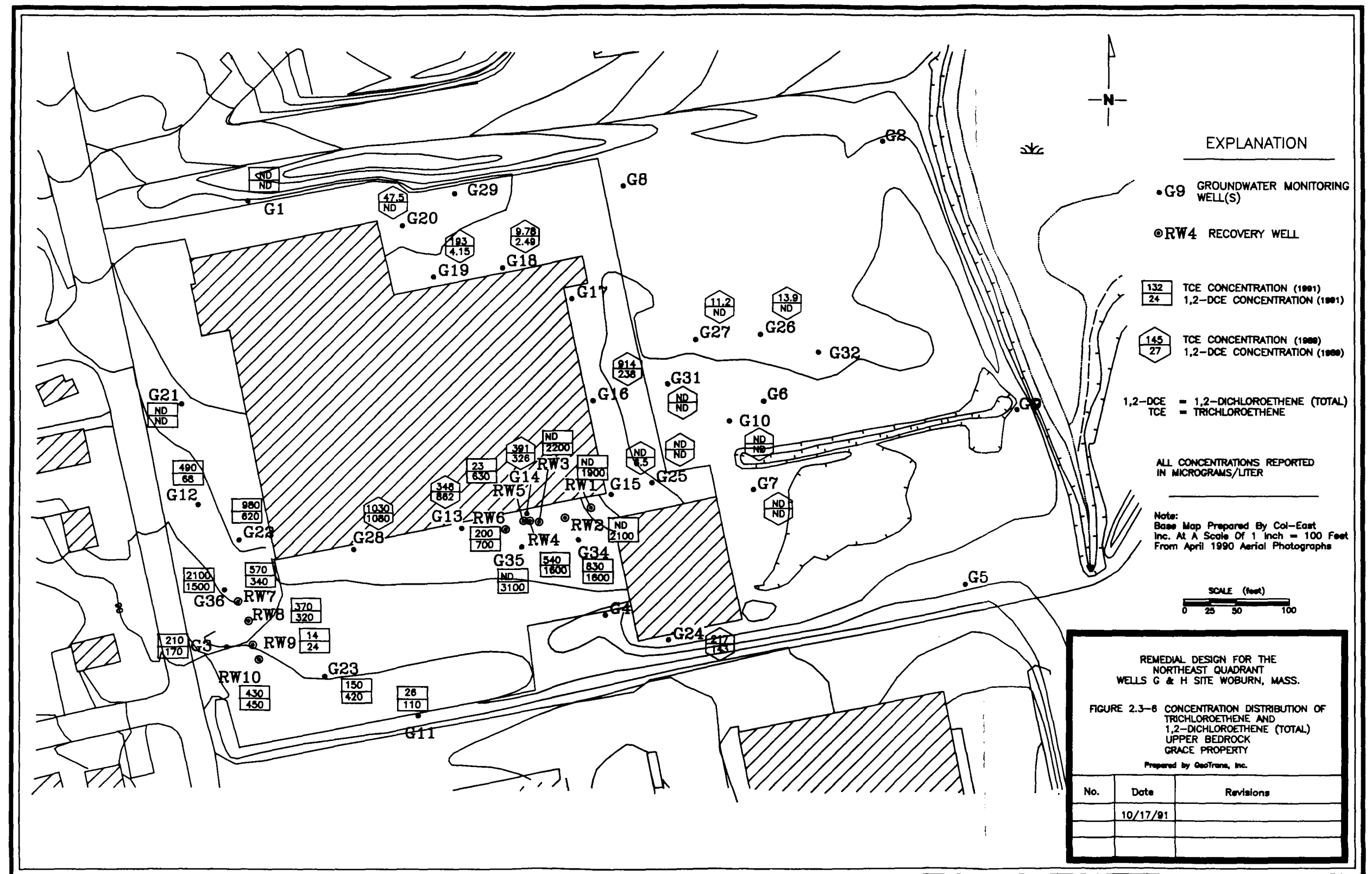
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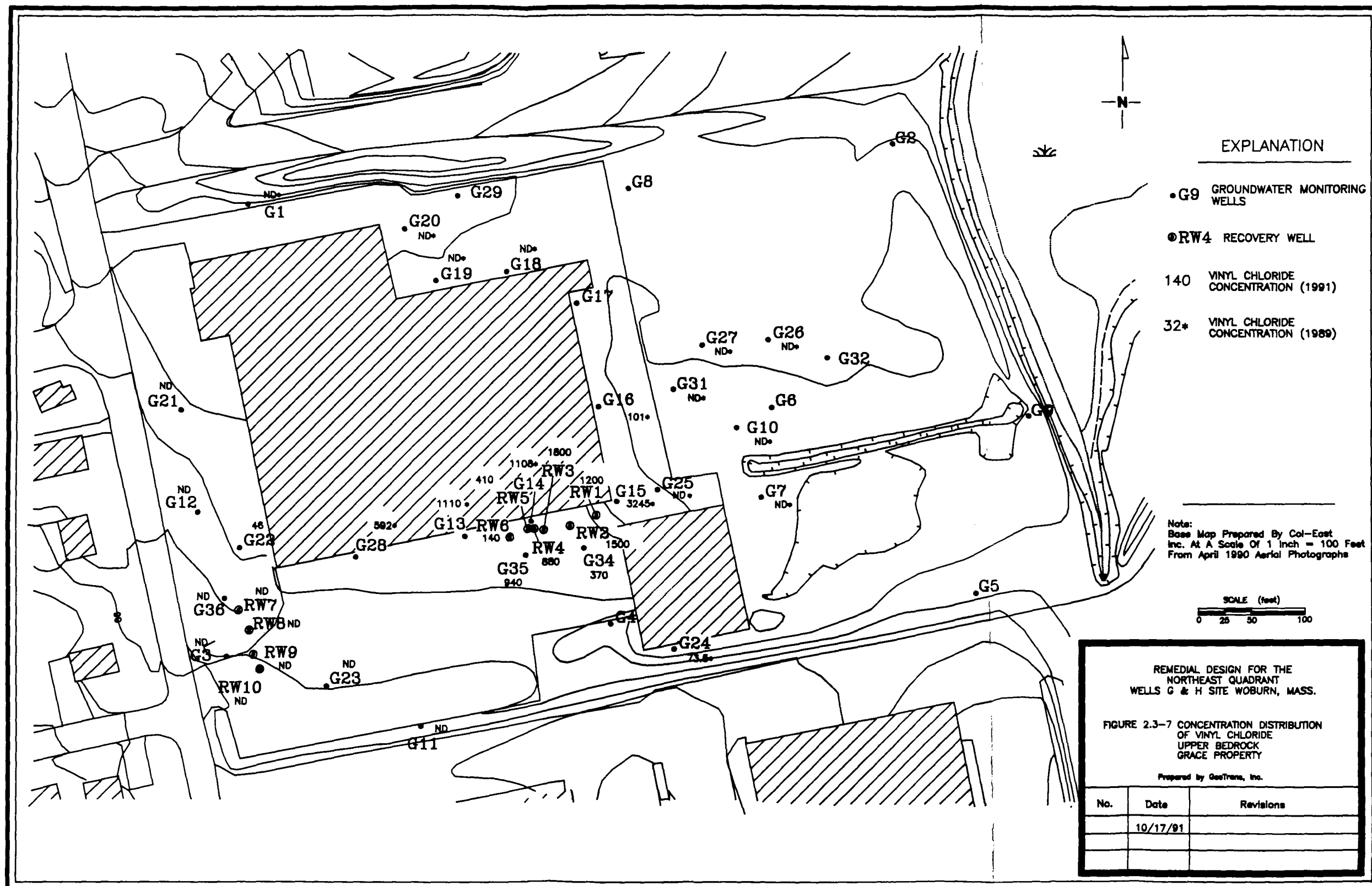
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TABLE 2.3-2
Historic Range of Metals Concentration Observed in
Samples from Grace Wells, (concentration in µg/L)

Compound	Minimum Concentration	Maximum Concentration
Aluminum	<80.00	2900.00
Antimony	<50.00	<50.00
Arsenic	<5.00	66.00
Barium	<2.00	33.00
Beryllium	<1.00	<1.00
Boron	<20.00	60.00
Cadmium	<2.00	7.00
Chromium	<10.00	1.40
Cobalt	<40.00	<40.00
Copper	<10.00	21.00
Iron	24.00	19000.00
Lead	<3.00	5.00
Manganese	11.00	5880.00
Mercury	<0.2	<2.00
Selenium	<5.0	.87
Silver	<10.00	<10.00
Sodium	173.00	49000.00
Thallium	<5.00	<5.00
Tin	0.00	0.00
Vanadium	<10.00	<10.00
Zinc	16.00	130.00



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feet) and subdivision of the flow section into an upper and lower flow zone. The width of the flow section remained the same because the lateral extent of the chemical plume is the same in 1991 as it was in 1985. The off-site water flux used in the calculations was about 50 percent greater than was used in the 1987 calculations as a result of the greater thickness of the flow section. The reduction in the calculated off-site chemical flux results from reduced chemical concentrations observed in the downgradient boundary monitoring wells in 1991 compared to 1985.

2.3.3 Northeast Quadrant

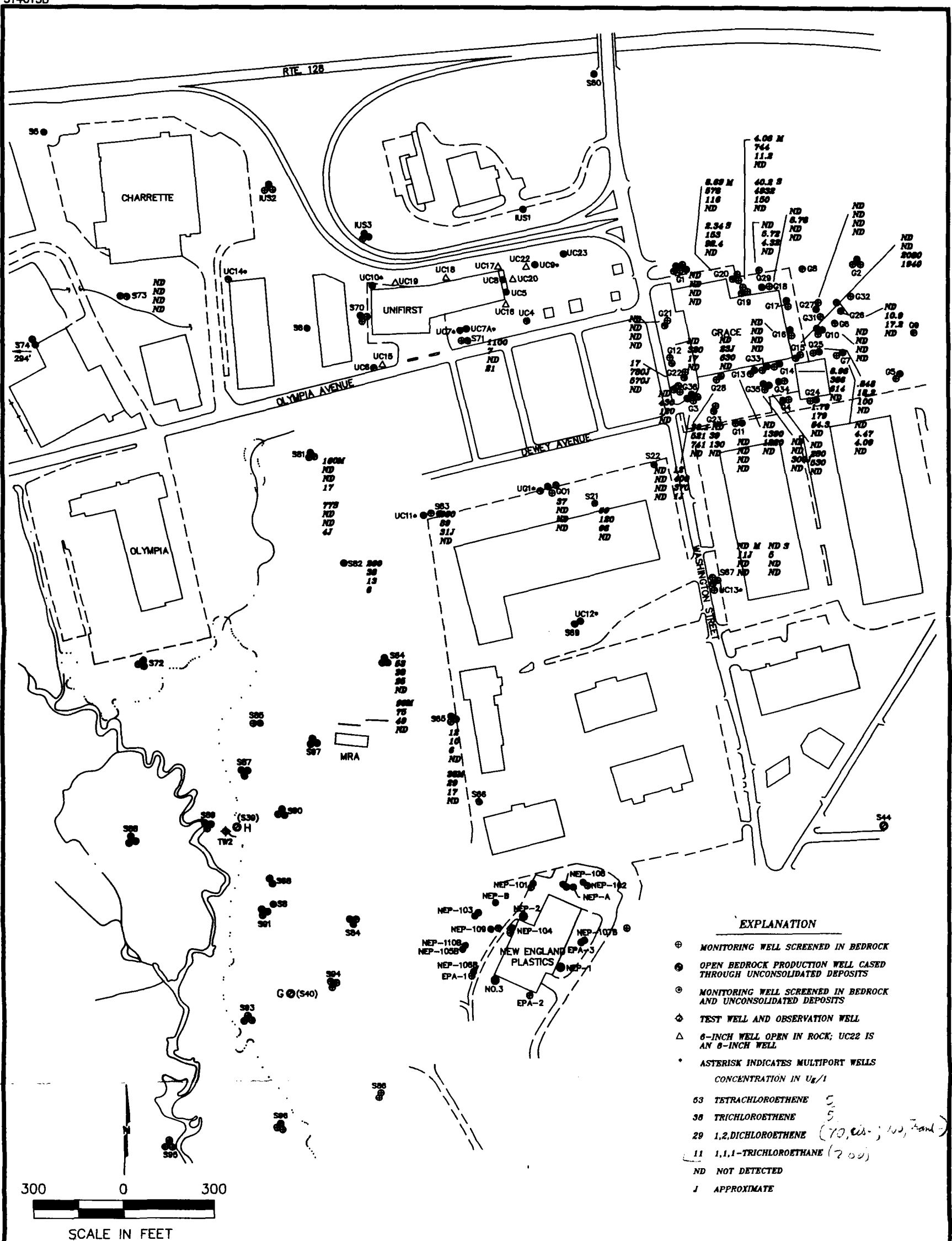
2.3.3.1 History

Monitoring wells were first installed and sampled at the Wells G & H Site in 1981 by EPA as part of the early studies responding to VOC contamination of wells G and H. Additional wells have been installed since 1981 by UniFirst, Grace, EPA, and New England Plastics to collect data for hydrogeologic and contaminant distribution characterization of areas within the Wells G & H Site. Most of the wells have been sampled several times since installation. Samples have been analyzed primarily for VOC, and selected samples have been analyzed for semi-volatiles, pesticides/PCB, metals, radionuclides, and other selected inorganic parameters. Analytical results from the past sampling indicate that in some areas of the Northeast Quadrant the ground water can be generally characterized as being contaminated with the VOC tetrachloroethene, trichloroethene, 1,2-dichloroethene, vinyl chloride, and 1,1,1-trichloroethane. A summary table of reported concentrations of these compounds for all wells in the Northeast Quadrant is included in Appendix F. Additional VOC have been detected at relatively low concentrations in some wells.

Analysis of ground-water samples collected during 1991 indicated the presence of tentatively identified compounds (TICs). The TICs include volatile and semi-volatile compounds and were reported for several wells. Two hypotheses regarding the source of the TICs are that they may be derived from ruptured Solnist packers or derived from localized contaminant sources. To attempt to identify the source of the TICs, approximately 50 shallow drive points are planned to be installed.

2.3.3.2 Unconsolidated Deposits: VOC and Metals

The areal distribution of the VOC trichloroethene, 1,2-dichloroethene, tetrachloroethene, and 1,1,1-trichloroethane is shown on Figure 2.3-8. In general, the concentrations and areal distribution of VOC in the unconsolidated deposits of the Northeast Quadrant have not changed



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FIGURE 2.3-8

AREAL DISTRIBUTION OF TETRACHLOROETHENE,
TRICHLOROETHENE, 1,2-DICHLOROETHENE
AND 1,1,1 TRICHLOROETHANE IN
UNCONSOLIDATED DEPOSITS

significantly since 1985. See Appendix F for a summary of selected VOC concentrations for all wells within the Northeast Quadrant.

The distribution of metals in the 1991 ground-water samples from the unconsolidated material shows no areal pathways. There is a very low occurrence of concentrations that are above the laboratory detection limit for the analyzed elements. The analyzed metals and cyanide, the minimum concentration or detection limit, and the maximum concentration reported are summarized in Table 2.3-3. The table also lists typical concentration values for these elements in ground water (Dragun, 1988). Only four samples from three wells installed in the unconsolidated materials resulted in metals concentrations above these typical values.

2.3.3.3 Bedrock: VOC and Metals

The areal distribution of the VOC trichloroethene, 1,2-dichloroethene, and tetrachloroethene in the bedrock is shown on Figure 2.3-9. Figures 2.3-10 through 2.3-12 are cross sections showing the vertical distribution of these compounds. The locations of the cross sections are shown on Figure 2.3-13. With the exception of wells S64D, S65D, and S66, the concentrations of these compounds in the shallow bedrock has changed little since the comprehensive sampling and analysis done in 1985. Tetrachloroethene concentrations in samples from the bedrock wells at well clusters S64, S65, and S66 have increased significantly since 1985. Table 2.3-4 lists the reported 1985 and 1991 tetrachloroethylene concentrations for these wells.

The distribution of metals in ground-water samples from the bedrock shows no areal patterns. There is a very low occurrence of concentration values that are above the laboratory detection limits for the analyzed elements. The analyzed metals and cyanide, the minimum concentrations or detection limits, and the maximum concentrations reported are summarized in Table 2.3-2 as well as a list of the typical concentrations for these elements in ground water (Dragun, 1988).

Twenty-one samples contained metals concentrations above these typical values. Eight of these were elevated sodium levels and eight others were elevated chromium levels. When the maximum concentration for each constituent from all wells was reviewed, it was noted that the highest values for antimony, chromium, lead, nickel, sodium, and zinc were detected in the sample from well UC14-2. Well UC14-2 is a relatively deep bedrock well located in the northwesterly portion of the Northeast Quadrant. The coincidence of highest concentrations of these six compounds at well UC14-2 will be considered further during the planned Central Area RI/FS.

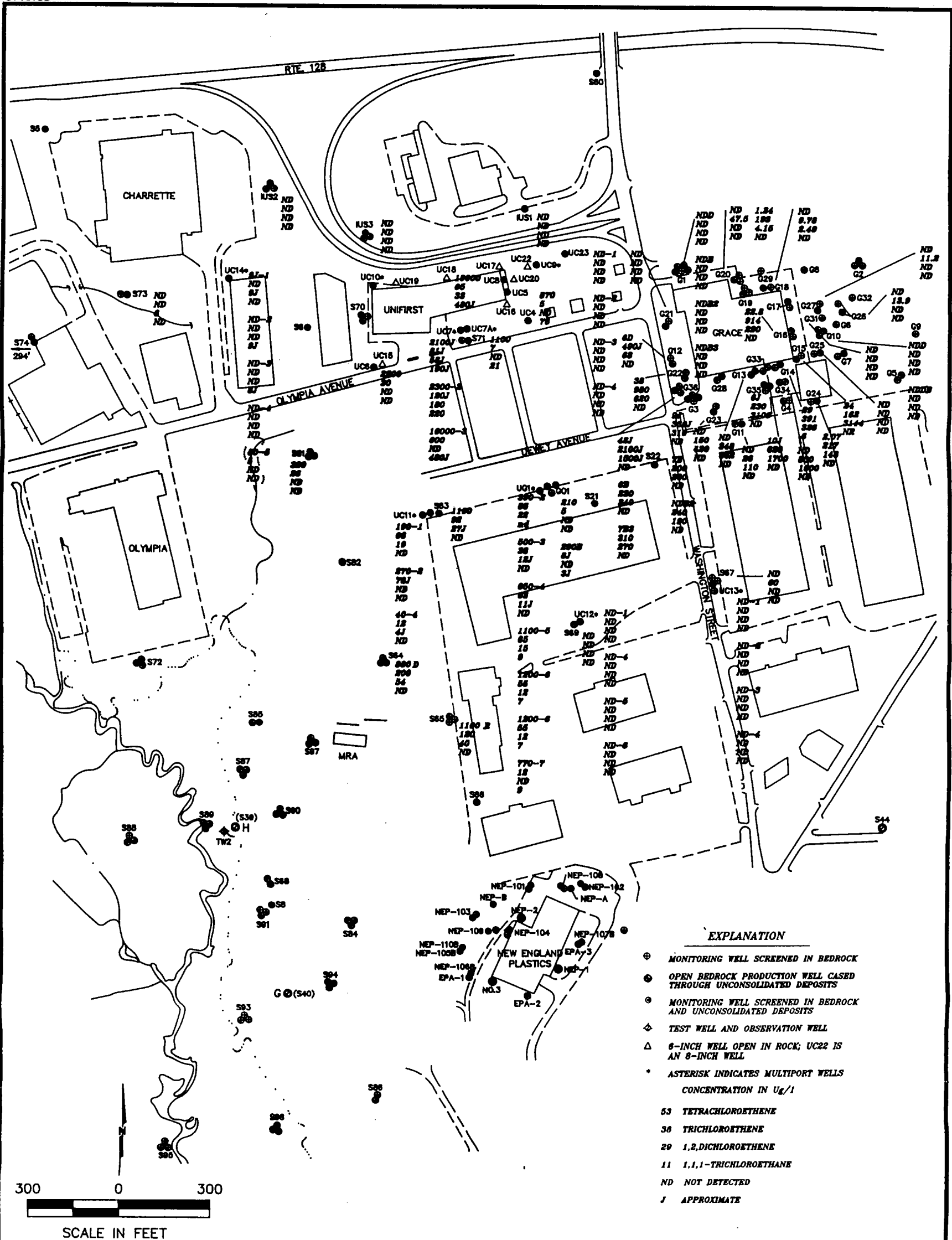
TABLE 2.3-3

Metals Concentrations for Ground Water in the Northeast Quadrant
(concentrations in µg/l)

Analyte	Detection Limit (ppb)	Maximum Value (ppb)	Typical Value ¹ (ppb)
Aluminum	95.6	822	<5.0-1000
Antimony	<3.5	.7	-
Arsenic	<1.5	25.8	<1.0-30
Barium	31.3	211	10-500
Beryllium	1.4	*	<10
Cadmium	<4	*	<1.0
Chromium	<11	7370	<1.0-5.0
Cobalt	7.9	19	<10
Copper	<23	21	<1.0-30
Cyanide	10	45.7	-
Iron	<237	9010	10-10,000
Lead	<6.5	30.6	<15
Magnesium	5000	18700	1000-50,000
Manganese	<25	3240	<1.0-1000
Mercury	0.2	*	<1.0
Nickel	10.6	40	<10-50
Potassium	1120	208	1000-10,000
Selenium	<0.9	11.8	<1.0-10
Silver	<30	*	<5.0
Sodium	5000	410000	500-120,000
Thallium	0.6	*	-
Vanadium	7.7	29	<1.0-10
Zinc	<173	1510	<10-2000

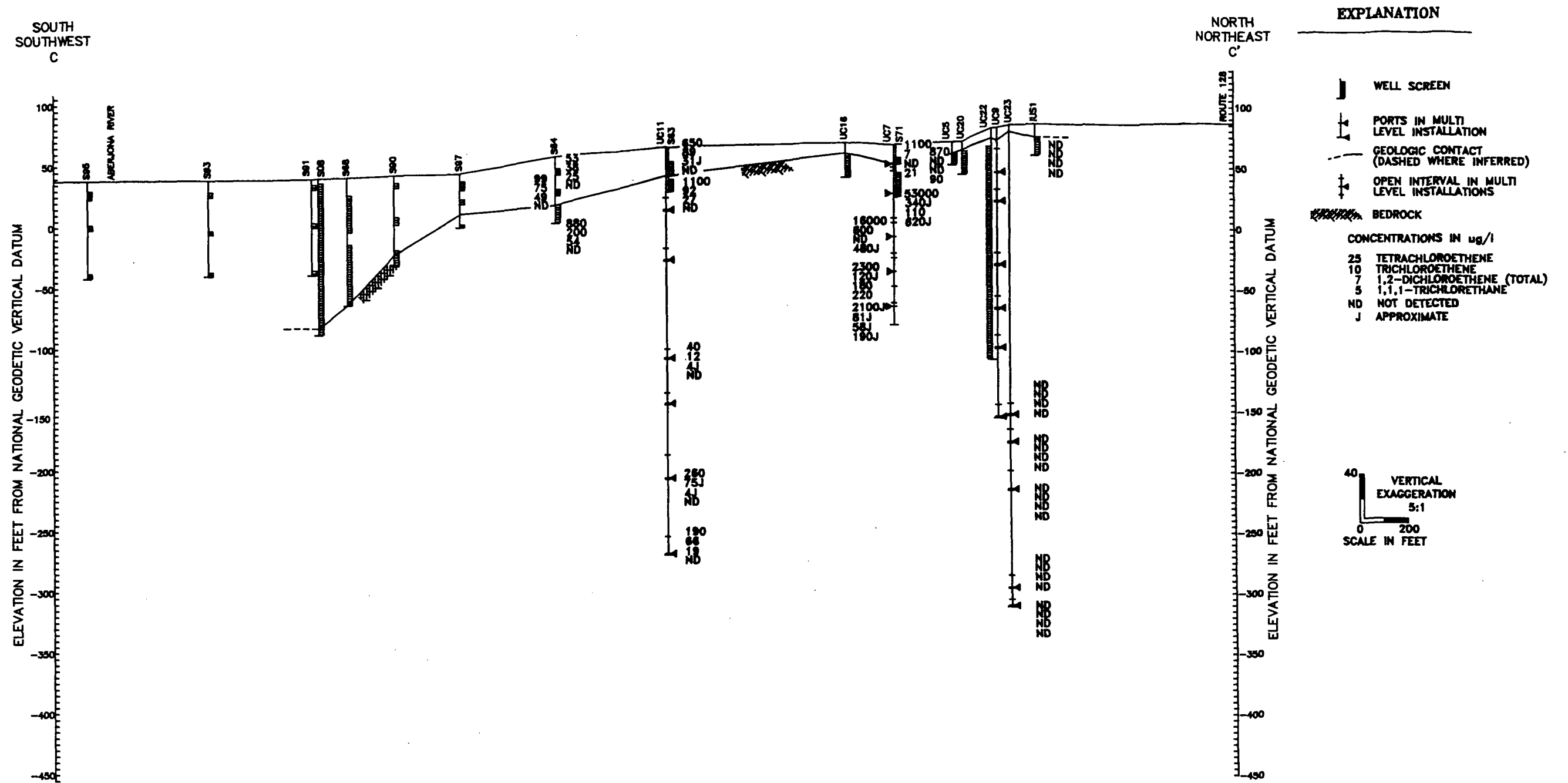
* No values above detection limit.

¹ Reference: Dragun, J. 1988. The Soil Chemistry of Hazardous Materials, p. 79.



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FIGURE 2.3-9
 AREAL DISTRIBUTION OF TETRACHLOROETHENE,
 TRICHLOROETHENE, 1,2-DICHLOROETHENE AND
 1,1,1-TRICHLOROETHANE IN BEDROCK



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FIGURE 2.3-10
CROSS SECTION C-C' SHOWING
CONCENTRATION OF TETRACHLOROETHENE,
TRICHLOROETHENE, 1,2-DICHLOROETHENE
AND 1,1,1-TRICHLOROETHANE

PREPARED BY GEOTRANS INC.

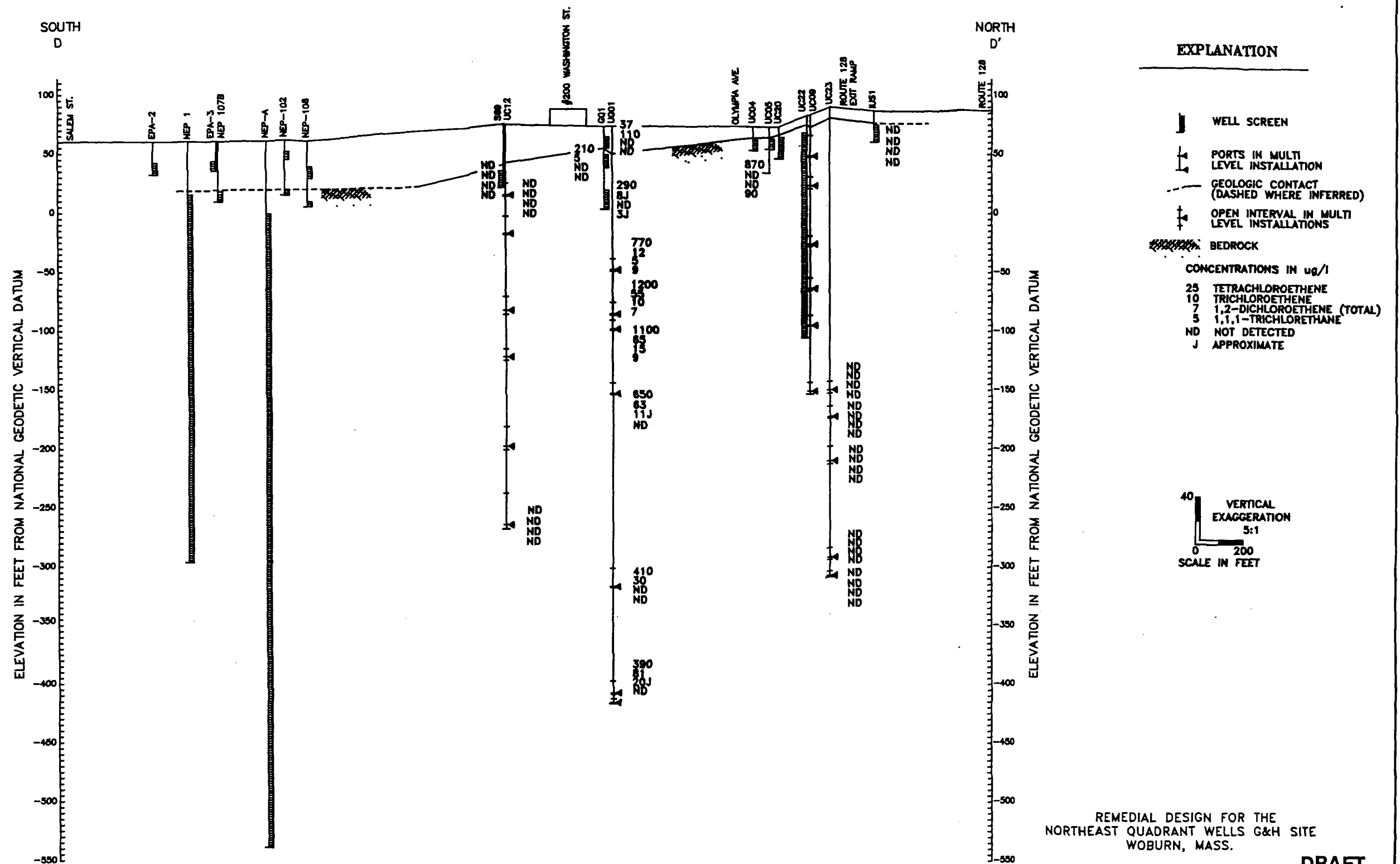
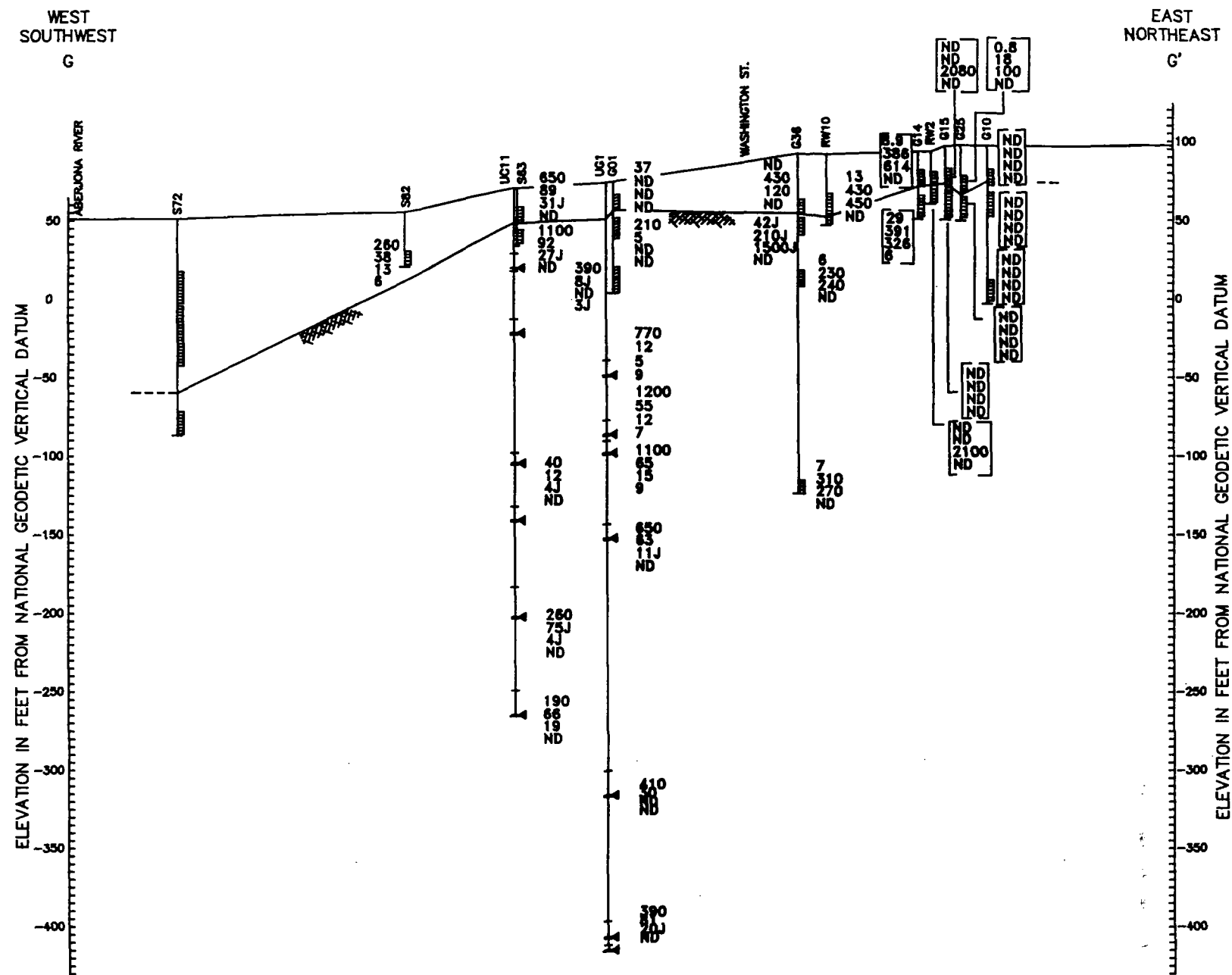


FIGURE 2.3-11
CROSS SECTION D-D' SHOWING
CONCENTRATION OF TETRACHLOROETHENE,
TRICHLOROETHENE, 1,2-DICHLOROETHENE
AND 1,1,1-TRICHLOROETHANE

PREPARED BY GEOTRANS INC.



EXPLANATION

- WELL SCREEN
- PORTS IN MULTI LEVEL INSTALLATION
- GEOLOGIC CONTACT (DASHED WHERE INFERRED)
- OPEN INTERVAL IN MULTI LEVEL INSTALLATIONS
- BEDROCK
- CONCENTRATIONS IN ug/l
 - 25 TETRACHLOROETHENE
 - 10 TRICHLOROETHENE
 - 7 1,2-DICHLOROETHENE (TOTAL)
 - 5 1,1,1-TRICHLOROETHANE
 - ND NOT DETECTED
 - J APPROXIMATE

SAMPLES COLLECTED IN 1989

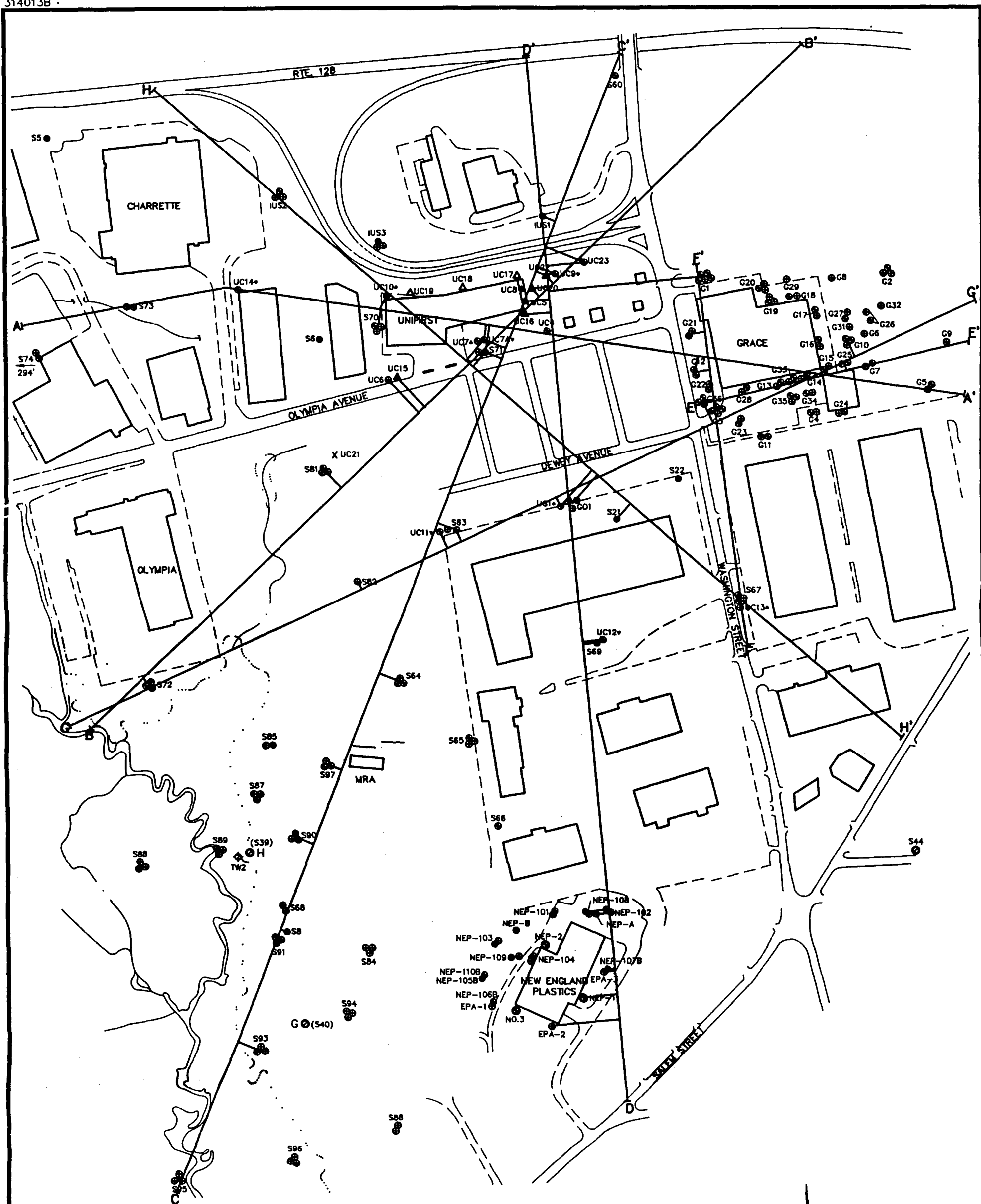
VERTICAL
EXAGGERATION
5:1
SCALE IN FEET

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FIGURE 2.3-12
Cross Section G-G' Showing Concentrations
of Tetrachloroethene, Trichloroethene,
1,2-Dichloroethene (Total), and 1,1,1-Trichloroethane

PREPARED BY GEOTRANS INC.



EXPLANATION

- MONITORING WELL SCREENED IN UNCONSOLIDATED DEPOSITS
- MONITORING WELL SCREENED IN BEDROCK
- OPEN BEDROCK PRODUCTION WELL CASED THROUGH UNCONSOLIDATED DEPOSITS
- ⊙ CASED AND OPEN WATER SUPPLY WELL SCREENED IN UNCONSOLIDATED DEPOSITS
- MONITORING WELL SCREENED IN BEDROCK AND UNCONSOLIDATED DEPOSITS
- ◆ TEST WELL & OBSERVATION WELL
- △ 6-INCH WELL OPEN IN ROCK; UC22 IS AN 8-INCH WELL
- ASTERISK INDICATES MULTIPOINT WELLS (e.g. UC10*)
- X UC21 IS A SEALED AND ABANDONED BOREHOLE

300 0 300

SCALE IN FEET

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Remedial Design
of the Northeast Quadrant
Wells G&H Site
Woburn, MA

FIGURE 2.3-13
Cross-Section Locations

Prepared by: ENSR Consulting and Engineering

TABLE 2.3-4

Comparison of 1985, 1990, and 1991 Tetrachloroethene
Concentrations in Wells S64D, S65D, and S66
(concentrations in µg/l)

Well	4/85	5/85	6/85	9/90	2/91
S64D	42J	43J	40J	1,600	880
S65D	16J	15.3	11	-	1,100
S66	3.2J	5.2	5.4	1,500	-

- Not sampled

J Approximate

3.0 PUMPING CONDITIONS

This chapter describes the hydrogeologic observations and evaluations made regarding the combined UniFirst/Grace remedial design investigation pilot study. The combined pilot test was based on the concept of ground-water extraction from a deep bedrock well (UC22) on the UniFirst property and pumping from both the unconsolidated deposits and shallow bedrock at two locations on the Grace property. The deep bedrock well was expected to create an areally extensive capture zone within the bedrock beneath and downgradient of both the UniFirst and Grace properties. The zone of capture would cause contaminated ground water from beneath the UniFirst, Grace, and Cummings properties to be collected by well UC22 and prevent migration of contaminated ground water from the Northeast Quadrant to the Aberjona River Valley. Pumping from the unconsolidated deposits and shallow bedrock wells on the Grace property would create a localized capture zone that complemented the larger and more regional capture zone of well UC22.

The results of the pilot test indicate that the expected performance of the combined extraction systems was realized. Well UC22 created a large capture zone which did extend beneath and sufficiently downgradient of both the UniFirst and Grace properties that it would likely prevent further migration of contamination off-site from the UniFirst property and from the Northeast Quadrant area toward the center of the Aberjona River Valley. Pumping from the Grace recovery wells resulted in a localized capture zone which was superimposed on the larger capture zone of well UC22. The localized capture zone effectively created a hydraulic barrier to off-site migration of contamination in the unconsolidated deposits and shallow bedrock beneath the Grace property.

The following sections of this chapter describe in more detail the observations and evaluations made regarding the hydrogeologic effects of the combined pilot testing.

3.1 Hydraulic Response to Pumping UC22

3.1.1 Hydraulic Response in the Unconsolidated Deposits

Well UC22 on the UniFirst property was pumped for 30 days (April 30 to May 30, 1991) at approximately 50 gallons per minute. The total volume of water pumped was approximately 2.2 million gallons. All monitoring well responses measured as part of this pumping test are presented as hydrographs in Appendix B and water elevation data in Appendix A and C. It is estimated that non-pumping related water level decline during the 30-day test was about one

Should we expect somewhat greater w/l declines in upland areas (natural)?

which wells, which media

foot. This is based on consistent water-level declines in monitoring wells near the Aberjona River and wells G and H which are distant from well UC22. The observed decline is likely due to the significant precipitation before the pumping test began. A total of 3.9 inches of precipitation were recorded between April 20 and 30, 1991 (NOAA, April, 1991). Precipitation data collected on the Grace property are shown on Figure 2.2-4. A summary of water-level changes and water elevation measured periodically during the 30-day pumping test is presented in Table 3.1-1. The table reflects water-level change since April 25, 1991, which was the date of a comprehensive water level monitoring event that occurred five days before the pumping of UC22 began. Nine of the wells on Table 3.1-1 reflect water level change since April 29, 1991, four days after the first comprehensive water level monitoring event. This delay was due to field conditions and Solnist well mechanical complications.

The potentiometric surface of shallow wells screened in the unconsolidated deposits on Day 30, the final day, of pumping is presented in Figure 3.1-1. Water-level elevations are shown on this figure and presented in Table 3.1-1. There is negligible change in water levels from pre-pumping conditions except on the Grace property. The change on the Grace property is primarily due to Grace pumping.

The drawdown response in the unconsolidated deposits was minor relative to the bedrock. The greatest drawdown occurred outside the UniFirst property boundary approximately 750 feet from UC22 at well GO1S. The drawdown in wells screened in the unconsolidated deposits on the UniFirst property ranged from a maximum of 0.7 feet in UC6 to no drawdown in S70S and S70M. The maximum drawdown recorded in the unconsolidated deposits in the Northeast Quadrant attributed to UC22 pumping was 1.9 feet in GO1S. The variation in the amount of drawdown in the unconsolidated deposits likely reflects variations in vertical permeability, gravity drainage rates of the unconsolidated deposits and the variable response of the bedrock ground water. This response is expected, as in the bedrock, to equilibrate over time and reveal a more uniform response in the unconsolidated deposits.

relate to background

3.1.2 Hydraulic Response in Bedrock

As expected from previous hydraulic tests, the hydraulic response in the bedrock was pronounced and varied with depth and distance from the pumping well. The maximum drawdown in UC22 was approximately 51 feet with drawdown on the UniFirst property ranging from 0.4 feet at S71D to 30 feet at UC9-2. The variable response with depth required representation with two potentiometric surface maps; one of the wells screened in the shallow bedrock, Figure 3.1-2, and a second of wells screened deeper in the bedrock which had a more significant response to pumping, Figure 3.1-3. While water-level declines due to pumping were less than 10 feet throughout the Northeast Quadrant in shallow bedrock wells, water-level

Do discussions in 4.6 take into account natural w/l decline?

TABLE 3.1-1

Well Response Summaries
Pilot Test, Woburn, MA
April - June 1991

Well	Screen or Packed Interval		Geologic Unit **	Water Elevation* Start	After 5 Days of Unifirst pumping				Before Grace Pumping		Before End Grace Pumping		End of Pilot Test				
	TOS	BOS			Date	W. Elev.	Date	WLC***	Elev.*	Date	WLC	Elev.*	Date	WLC	Elev.*		
IUS1	76	61	SHB	4/25/91	74.85	5/6/91	1.47	73.38	5/10/91	1.68	73.17	5/20/91	2.91	71.94	5/30/91	4.21	70.64
IUS2A	-10	-28	SHB	4/25/91	56.14	5/6/91	0.78	55.36	5/10/91	0.85	55.29	5/20/91	1.33	54.81	5/30/91	1.62	54.52
IUS2B	21	6	DR	4/25/91	56.44	5/6/91	0.25	56.19	5/10/91	0.42	56.02	5/20/91	0.84	55.60	5/30/91	1.12	55.32
IUS2C	51	41	DR	4/25/91	56.92	5/6/91	0.04	56.88	5/10/91	0.34	56.58	5/20/91	0.76	56.16	5/30/91	1.04	55.88
IUS3A	20	4	DR/SHB	4/25/91	60.01	5/6/91	0.69	59.32	5/10/91	0.80	59.21	5/20/91	1.34	58.67	5/30/91	1.83	58.18
IUS3B	37	22	DR	4/25/91	59.90	5/6/91	0.16	59.74	5/10/91	0.27	59.63	5/20/91	0.75	59.15	5/30/91	1.20	58.70
IUS3C	62	42	DR	4/25/91	60.27	5/6/91	0.03	60.24	5/10/91	0.20	60.07	5/20/91	0.86	59.41	5/30/91	1.43	58.84
UC4	64	54	SHB	4/25/91	68.48	5/6/91	0.75	67.73	5/10/91	0.91	67.57	5/20/91	1.28	67.20	5/30/91	1.65	66.83
UC5	64	54	DR/SHB	4/25/91	65.27	5/6/91	2.21	63.06	5/10/91	2.23	63.04	5/20/91	2.24	63.03	5/30/91	2.26	63.01
UC6	35	25	DR	4/25/91	57.52	5/6/91	0.85	56.67	5/10/91	0.94	56.58	5/20/91	1.31	56.21	5/30/91	1.70	55.82
UC7A-1	-60	-77	DPB	4/25/91	64.44	5/6/91	25.22	39.22	5/10/91	29.07	35.37	5/20/91	28.09	36.35	5/30/91	29.68	34.76
UC7A-2	-21	-46	DPB	4/25/91	64.47	5/6/91	25.16	39.31	5/10/91	26.04	38.43	5/20/91	27.92	36.55	5/30/91	29.39	35.08
UC7A-3	6	-18	DPB	4/25/91	62.93	5/6/91	15.40	47.53	5/10/91	16.08	46.85	5/20/91	17.45	45.48	5/30/91	18.82	44.11
UC7A-4	50	9	SHB	4/25/91	61.55	5/6/91	6.68	54.87	5/10/91	7.06	54.49	5/20/91	7.94	53.61	5/30/91	8.84	52.71
UC7A-5	71	53	SHB	4/29/91	67.27	5/6/91	-0.43	67.70	5/10/91	-0.46	67.73	5/20/91	-0.47	67.74	5/30/91	-0.45	67.72
UC8	69	54	DR/SHB	4/25/91	69.20	5/6/91	-0.13	69.33	5/10/91	-0.01	69.21	5/20/91	0.74	68.46	5/30/91	1.49	67.71
UC9-2	-86	-97	DPB	4/25/91	70.92	5/4/91	29.90	41.02	5/10/91	30.13	40.79	5/17/91	29.90	41.02	5/24/91	30.59	40.33
UC9-3	-57.57	-64.89	DPB	4/25/91	NM												
UC9-4	-18	-28	DPB	4/25/91	63.93	5/4/91	25.30	38.63	5/10/91	25.99	37.94	5/17/91	27.37	36.56	5/24/91	28.75	35.18
UC9-6	67	47	SHB	4/25/91	69.45	5/4/91	5.52	63.93	5/10/91	5.75	63.70	5/17/91	6.36	63.09	5/24/91	6.90	62.55
UC10-1	-161	-173	DPB	4/29/91	64.44	5/4/91	24.61	39.83	5/10/91	24.61	39.83	5/17/91	24.38	40.06	5/24/91	24.84	39.60
UC10-2	-145	-157	DPB	4/25/91	62.94	5/4/91	19.09	43.85	5/10/91	19.78	43.16	5/17/91	20.47	42.47	5/24/91	22.08	40.86
UC10-3	-102	-112	DPB	4/25/91	60.60	5/4/91	10.81	49.79	5/10/91	9.39	51.21	5/17/91	17.25	43.35	5/24/91	11.27	49.33
UC10-4	-78	-88	DPB	4/25/91	63.53	5/4/91	13.80	49.73	5/10/91	13.34	50.19	5/17/91	14.49	49.04	5/24/91	12.19	51.34
UC10-5	-55	-59	DPB	4/25/91	60.03	5/4/91	5.75	54.28	5/10/91	6.44	53.59	5/17/91	7.13	52.90	5/24/91	10.84	49.19
UC10-6	-8	-23	DPB	4/25/91	58.24	5/4/91	3.68	54.56	5/10/91	3.45	54.79	5/17/91	-2.01	60.25	5/24/91	1.21	57.03
UC11-1	-250	-264	DPB	4/29/91	32.17	5/4/91	0.09	32.08	5/10/91	-1.29	33.46	5/17/91	-0.83	33.00	5/24/91	-0.14	32.31
UC11-2	-183	-203	DPB	4/25/91	60.64	5/4/91	11.73	48.91	5/10/91	12.65	47.99	5/17/91	12.65	47.99	5/24/91	13.11	47.53
UC11-4	-96	-103	DPB	4/29/91	49.77	5/4/91	0.92	48.85	5/10/91	1.15	48.62	5/17/91	0.69	49.08	5/24/91	0.69	49.08
UC11-6	29	19	DPB	4/25/91	61.15	5/4/91	4.60	56.55	5/10/91	5.98	55.17	5/17/91	4.60	56.55	5/24/91	4.83	56.32
UC12-1	-238	-268	DPB	4/29/91	60.96	5/4/91	12.88	48.08	5/10/91	25.07	35.89	5/17/91	25.07	35.89	5/24/91	26.45	34.51
UC12-4	-72	-84	DPB	4/25/91	63.83	5/4/91	13.80	50.03	5/10/91	12.65	51.18	5/17/91	14.03	49.80	5/24/91	14.03	49.80
UC12-5	-3	-20	DPB	4/25/91	64.23	5/4/91	NM		5/10/91	NM		5/17/91	NM		5/24/91	NM	
UC12-6	24	16	DPB	4/25/91	62.19	5/4/91	2.53	59.66	5/10/91	2.53	59.66	5/17/91	3.22	58.97	5/24/91	4.60	57.59
UC14-1	-267	-280	DPB	4/25/91	56.81	5/4/91	1.91	54.90	5/10/91	1.80	55.01	5/17/91	2.61	54.20	5/24/91	2.86	53.95

TABLE 3.1-1 (continued)

Well	Screen or Packed Interval		Geologic Unit **	Water Elevation* Start		After 5 Days of Unifirst pumping			Before Grace Pumping		Before End Grace Pumping		End of Pilot Test				
	TOS	BOS		Date	W. Elev.	Date	WLC***	Elev.*	Date	WLC	Elev.*	Date	WLC	Elev.*			
UC14-2	-223	-236	DPB	4/25/91	63.14	5/4/91	1.16	61.98	5/10/91	1.12	62.02	5/17/91	4.11	59.03	5/24/91	2.59	60.55
UC14-3	-164	-176	DPB	4/25/91	50.29	5/4/91	1.36	48.91	5/10/91	1.25	49.04	5/17/91	2.10	48.19	5/24/91	2.26	48.03
UC14-4	-86	-98	DPB	4/25/91	47.70	5/4/91	0.25	47.45	5/10/91	-0.08	47.78	5/17/91	0.67	47.03	5/24/91	0.71	46.99
UC14-5	-17	-39	DPB	4/25/91	49.17	5/4/91	0.23	48.94	5/10/91	-0.15	49.32	5/17/91	0.59	48.58	5/24/91	0.55	48.62
UC15S	-10	-20	DPB	4/25/91	48.87	5/6/91	-2.40	51.27	5/10/91	-1.04	50.81	5/20/91	-0.99	49.86	5/30/91	-0.16	49.03
UC15D	-202	-212	DPB	4/25/91	35.61	5/6/91	-9.17	44.78	5/10/91	-7.59	43.20	5/20/91	-5.61	41.22	5/30/91	-4.01	39.62
UC16	62	44	SHB	4/25/91	64.38	5/6/91	9.10	55.28	5/10/91	8.97	55.41	5/20/91	8.77	55.61	5/30/91	8.01	56.37
UC17	62	44	SHB	4/25/91	66.80	5/6/91	0.60	66.20	5/10/91	0.54	66.26	5/20/91	1.02	65.78	5/30/91	1.67	65.13
UC18	60	40	SHB	4/25/91	62.80	5/6/91	9.11	53.69	5/10/91	9.92	52.88	5/20/91	11.21	51.59	5/30/91	11.93	50.87
UC19	31	12	SHB	4/25/91	61.75	5/6/91	7.86	53.89	5/10/91	8.35	53.40	5/20/91	9.27	52.48	5/30/91	10.07	51.68
UC20	65	46	SHB	4/25/91	67.24	5/6/91	0.93	66.31	5/10/91	1.33	65.91	5/20/91	2.25	64.99	5/30/91	2.97	64.27
UC22	70	-106	SHB	4/25/91	66.84	5/6/91	45.25	21.59	5/10/91	47.49	19.35	5/20/91	50.33	16.51	5/30/91	51.71	15.13
UC23-1	-303	-308	DPB	4/25/91	84.20	5/6/91	-0.84	85.04	5/10/91	-1.39	85.59	5/20/91	-2.44	86.64	5/30/91	-2.97	87.17
UC23-2	-283	-293	DPB	4/25/91	82.43	5/6/91	13.55	68.88	5/10/91	13.60	68.83	5/20/91	14.34	68.09	5/30/91	10.16	72.27
UC23-3	-197	-213	DPB	4/25/91	64.91	5/6/91	22.81	42.10	5/10/91	23.67	41.24	5/20/91	25.06	39.25	5/30/91	27.26	37.65
UC23-4	-164	-174	DPB	4/25/91	64.84	5/6/91	22.15	42.69	5/10/91	23.51	41.33	5/20/91	25.51	39.33	5/30/91	27.24	37.60
UC23-5	-141	-152	DPB	4/25/91	66.03	5/6/91	23.83	42.20	5/10/91	24.69	41.34	5/20/91	26.60	39.43	5/30/91	28.39	37.64
UG1-1	-413	-427	DPB	4/25/91	NM	5/4/91	NM	28.78	5/10/91	NM	29.22	5/17/91	NM	25.58	5/30/91	NM	29.96
UG1-2	-397	-408	DPB	4/25/91	63.03	5/4/91	13.71	49.32	5/10/91	14.29	48.74	5/17/91	15.32	47.71	5/30/91	16.84	46.19
UG1-3	-301	-317	DPB	4/25/91	63.12	5/4/91	13.41	49.71	5/10/91	14.06	49.06	5/17/91	15.01	48.11	5/30/91	16.39	46.73
UG1-4	-143	-154	DPB	4/25/91	64.02	5/4/91	19.62	44.20	5/10/91	18.93	45.09	5/17/91	20.00	44.02	5/30/91	22.02	42.00
UG1-5	-91	-99	DPB	4/25/91	61.50	5/4/91	17.48	44.02	5/10/91	16.57	44.93	5/17/91	19.50	42.00	5/30/91	21.49	40.01
UG1-6	-75	-86	DPB	4/25/91	65.44	5/4/91	21.36	44.08	5/10/91	22.25	43.19	5/17/91	23.34	42.10	5/30/91	25.53	39.91
UG1-7	-38	-48	DPB	4/25/91	64.18	5/4/91	17.60	46.58	5/10/91	18.24	45.94	5/17/91	19.01	45.17	5/30/91	24.02	40.16
G1D	56	46	SHB	4/25/91	88.75	5/6/91	0.41	88.34	5/10/91	0.59	88.16	5/20/91	1.23	87.52	5/30/91	1.87	86.88
G1DB	7	2	DPB	4/25/91	88.19	5/6/91	1.24	86.95	5/10/91	1.38	86.81	5/20/91	-0.29	86.12	5/30/91	2.71	85.48
G1DB2	-37	-42	DPB	4/25/91	80.87	5/6/91	11.39	69.48	5/10/91	8.98	71.89	5/20/91	14.85	66.01	5/30/91	15.02	65.85
G1DB3	-87	-92	DPB	4/25/91	96.49	5/6/91	-0.02	96.51	5/10/91	-0.02	96.51	5/20/91	0.13	96.36	5/30/91	-0.02	96.51
G1S	71	61	DR	4/25/91	89.51	5/6/91	0.30	89.21	5/10/91	0.44	89.07	5/20/91	1.02	88.48	5/30/91	1.66	87.85
GO1D	49	38	SHB	4/25/91	60.55	5/6/91	1.76	58.79	5/10/91	2.18	58.37	5/20/91	3.15	57.40	5/30/91	3.98	56.57
GO1DB	18	3	DPB	4/25/91	63.50	5/6/91	16.72	46.78	5/10/91	17.95	45.55	5/20/91	19.68	43.82	5/30/91	21.22	42.28
GO1S	65	55	DR	4/25/91	60.37	5/6/91	0.89	59.48	5/10/91	1.26	59.11	5/20/91	2.05	58.32	5/30/91	2.91	57.46
G2D	58	48	SHB	4/25/91	90.95	5/6/91	0.13	90.82	5/10/91	0.19	90.76	5/20/91	0.33	90.62	5/30/91	0.49	90.46
G2M	74	69	DR	4/25/91	91.31	5/6/91	0.33	90.96	5/10/91	0.41	90.90	5/20/91	0.74	90.57	5/30/91	0.92	90.39
G2S	89	79	DR	4/25/91	91.31	5/6/91	0.39	90.92	5/10/91	0.44	90.87	5/20/91	0.76	90.55	5/30/91	0.92	90.39

TABLE 3.1-1 (continued)

Well	Screen or Packed Interval		Geologic Unit **	Water Elevation*		After 5 Days of Unifirst pumping		Before Grace Pumping		Before End Grace Pumping		End of Pilot Test					
	TOS	BOS		Date	W. Elev.	Date	WLC***	Elev.*	Date	WLC	Elev.*	Date	WLC	Elev.*			
G3D	45	30	SHB	4/25/91	72.16	5/6/91	2.29	69.87	5/10/91	2.60	69.56	5/20/91	6.97	65.19	5/30/91	4.41	67.75
G3DB	6	-9	DPB	4/25/91	71.07	5/6/91	4.20	66.87	5/10/91	4.86	66.21	5/20/91	7.60	63.47	5/30/91	6.96	64.11
G3DB2	-63	-68	DPB	4/25/91	55.95	5/6/91	0.49	55.46	5/10/91	2.45	53.50	5/20/91	4.99	50.96	5/30/91	6.84	49.11
G3S	69	54	DR	4/25/91	72.17	5/6/91	0.57	71.60	5/10/91	0.70	71.47	5/20/91	4.04	68.13	5/30/91	2.11	70.06
G4D	64	49	SHB	4/25/91	80.68	5/6/91	-0.09	80.77	5/10/91	0.04	80.64	5/20/91	1.19	79.48	5/30/91	1.24	79.43
G4S	78	68	DR	4/25/91	84.91	5/6/91	0.17	84.74	5/10/91	0.23	84.68	5/20/91	2.66	82.25	5/30/91	2.09	82.82
G5D	68	53	SHB	4/25/91	86.95	5/6/91	0.21	86.74	5/10/91	0.26	86.69	5/20/91	0.56	86.39	5/30/91	0.66	86.29
G5S	82	72	DR	4/25/91	86.72	5/6/91	0.18	86.54	5/10/91	0.21	86.51	5/20/91	0.48	86.24	5/30/91	0.61	86.11
G6S	ND	86	DR	4/25/91	91.72	5/6/91	1.15	90.57	5/10/91	1.44	90.28	5/20/91	2.06	89.65	5/30/91	2.40	89.32
G7D	60	45	SHB	4/25/91	89.29	5/6/91	-0.48	89.77	5/10/91	-0.34	89.63	5/20/91	0.19	89.09	5/30/91	0.42	88.86
G7S	91	76	DR	4/25/91	89.97	5/6/91	0.94	89.03	5/10/91	1.13	88.84	5/20/91	1.70	88.27	5/30/91	2.06	87.91
G8S	64	54	DR	4/25/91	92.82	5/6/91	-2.67	95.49	5/10/91	-2.66	95.48	5/20/91	-2.07	94.89	5/30/91	-1.71	94.53
G9S	82	77	DR	4/25/91	90.60	5/6/91	0.24	90.36	5/10/91	0.25	90.35	5/20/91	0.49	90.11	5/30/91	0.64	89.96
G10D	67	52	SHB	4/25/91	90.60	5/6/91	0.71	89.89	5/10/91	0.86	89.74	5/20/91	1.41	89.19	5/30/91	1.64	88.96
G10S	82	72	DR	4/30/91	90.76	5/6/91	-0.02	90.78	5/10/91	0.14	90.62	5/20/91	0.71	90.05	5/30/91	1.03	89.73
G10DB	12	-3	DPB	4/30/91	89.80	5/6/91	-0.09	89.89	5/10/91	0.09	89.71	5/20/91	0.61	89.19	5/30/91	0.86	88.94
G11D	62	47	SHB	4/25/91	74.66	5/6/91	0.13	74.53	5/10/91	0.23	74.43	5/20/91	1.33	73.33	5/30/91	1.11	73.55
G11S	75	70	DR	4/25/91	75.63	5/6/91	0.60	75.03	5/10/91	0.70	74.93	5/20/91	1.05	74.58	5/30/91	1.11	74.61
G12D	58	48	SHB	4/25/91	73.05	5/6/91	2.43	70.62	5/10/91	2.82	70.23	5/20/91	4.55	68.50	5/30/91	4.55	68.50
G12S	78	68	DR	4/25/91	75.13	5/6/91	0.24	74.89	5/10/91	0.31	74.82	5/20/91	1.14	73.98	5/30/91	1.25	73.88
G13D	57	42	SHB	4/25/91	81.32	5/6/91	-0.18	81.50	5/10/91	-0.01	81.33	5/20/91	5.05	76.27	5/30/91	1.27	80.05
G13S	77	67	DR	4/25/91	78.82	5/6/91	-0.13	78.95	5/10/91	-0.12	78.94	5/20/91	0.92	77.90	5/30/91	1.28	77.54
G14D	66	52	SHB	4/25/91	82.01	5/6/91	-0.23	82.24	5/10/91	-0.14	82.15	5/20/91	6.28	75.73	5/30/91	1.49	80.52
G14S	82	72	DR	4/25/91	82.42	5/6/91	-0.33	82.75	5/10/91	-0.30	82.72	5/20/91	5.44	76.98	5/30/91	1.61	80.81
G15D	72	51	SHB	4/25/91	85.68	5/6/91	-0.13	85.81	5/10/91	-0.04	85.72	5/20/91	3.86	81.82	5/30/91	1.40	84.28
G15S	84	74	DR	4/25/91	88.42	5/6/91	-0.03	88.45	5/10/91	0.03	88.39	5/20/91	1.24	87.18	5/30/91	0.84	87.58
G16D	54	39	SHB	4/25/91	84.83	5/6/91	-0.20	85.03	5/10/91	-0.13	84.96	5/20/91	4.02	80.81	5/30/91	1.22	83.61
G16S	78	68	DR	4/25/91	91.36	5/6/91	0.30	91.06	5/10/91	-0.54	91.90	5/20/91	-0.06	91.42	5/30/91	0.15	91.21
G17D	41	26	SHB	4/25/91	95.35	5/6/91	-0.16	95.51	5/10/91	-0.11	95.46	5/20/91	0.36	94.98	5/30/91	0.67	94.67
G17S	61	51	DR	4/25/91	95.58	5/6/91	0.65	94.93	5/10/91	0.54	95.04	5/20/91	1.18	94.40	5/30/91	1.51	94.07
G18D	61	46	SHB	4/25/91	94.01	5/6/91	0.23	93.78	5/10/91	-0.11	94.12	5/20/91	0.79	93.22	5/30/91	1.16	92.85
G18S	76	66	DR	4/25/91	94.99	5/6/91	0.26	94.73	5/10/91	-0.17	95.16	5/20/91	0.82	94.17	5/30/91	1.13	93.86
G19D	39	24	SHB	4/25/91	89.18	5/6/91	0.22	88.96	5/10/91	0.01	89.17	5/20/91	1.04	88.14	5/30/91	1.59	87.59
G19M	64	54	DR	4/25/91	90.19	5/6/91	0.25	89.94	5/10/91	-0.03	90.22	5/20/91	0.96	89.23	5/30/91	1.46	88.73
G19S	88	78	DR	4/25/91	94.21	5/6/91	0.21	94.00	5/10/91	-0.09	94.30	5/20/91	0.77	93.43	5/30/91	1.11	93.10

TABLE 3.1-1 (continued)

Well	Screen or Packed Interval		Geologic Unit **	Water Elevation*		After 5 Days of Unifirst pumping			Before Grace Pumping		Before End Grace Pumping		End of Pilot Test				
	TOS	BOS		Date	W. Elev.	Date	WLC***	Elev.*	Date	WLC	Elev.*	Date	WLC	Elev.*			
G20D	27	12	SHB	4/25/91	88.76	5/6/91	0.50	88.26	5/10/91	0.63	88.13	5/20/91	1.31	87.44	5/30/91	1.89	86.86
G20M	48	38	DR	4/25/91	88.87	5/6/91	0.46	88.41	5/10/91	0.53	88.34	5/20/91	1.21	87.66	5/30/91	1.79	87.08
G20S	72	62	DR	4/25/91	92.14	5/6/91	0.45	91.69	5/10/91	0.15	91.99	5/20/91	0.77	91.37	5/30/91	1.24	90.90
G21D	61	46	SHB	4/25/91	73.18	5/6/91	2.66	70.52	5/10/91	3.03	70.15	5/20/91	4.70	68.47	5/30/91	4.86	68.32
G21S	76	66	DR	4/25/91	75.67	5/6/91	0.15	75.52	5/10/91	0.25	75.42	5/20/91	0.82	74.85	5/30/91	1.03	74.64
G22D	57	42	SHB	4/25/91	73.58	5/6/91	1.47	72.11	5/10/91	1.75	71.83	5/20/91	4.02	69.56	5/30/91	3.23	70.35
G22S	77	62	DR	4/25/91	74.54	5/6/91	0.30	74.24	5/10/91	0.40	74.14	5/20/91	2.21	72.33	5/30/91	1.43	73.11
G23D	59	44	SHB	4/25/91	74.62	5/6/91	0.22	74.40	5/10/91	0.12	74.50	5/20/91	1.46	73.15	5/30/91	1.25	73.36
G23S	75	65	DR	4/25/91	74.48	5/6/91	0.18	74.30	5/10/91	0.23	74.25	5/20/91	1.43	73.04	5/30/91	1.17	73.30
G24D	64	49	SHB	4/25/91	85.70	5/6/91	0.10	85.60	5/10/91	0.17	85.53	5/20/91	2.43	83.27	5/30/91	1.76	83.94
G24S	80	70	DR	4/25/91	85.69	5/6/91	0.11	85.58	5/10/91	0.19	85.50	5/20/91	0.45	85.23	5/30/91	1.77	83.92
G25D	65	50	SHB	4/25/91	90.56	5/6/91	0.70	89.86	5/10/91	0.90	89.66	5/20/91	1.36	89.20	5/30/91	1.60	88.96
G25S	77	67	DR	4/25/91	90.68	5/6/91	0.25	90.43	5/10/91	0.35	90.33	5/20/91	1.02	89.66	5/30/91	1.14	89.54
G26D	70	55	SHB	4/25/91	92.28	5/6/91	0.77	91.51	5/10/91	0.99	91.29	5/20/91	1.61	90.67	5/30/91	1.95	90.33
G26S	86	76	DR	4/25/91	92.35	5/6/91	1.06	91.29	5/10/91	1.36	90.99	5/20/91	1.91	90.43	5/30/91	2.17	90.17
G27D	72	57	SHB	4/25/91	93.74	5/6/91	0.32	93.42	5/10/91	0.41	93.33	5/20/91	0.81	92.92	5/30/91	1.11	92.63
G27S	86	76	DR	4/25/91	94.54	5/6/91	0.83	93.91	5/10/91	0.64	93.90	5/20/91	1.55	92.99	5/30/91	2.04	92.50
G28D	64	50	SHB	4/25/91	75.39	5/6/91	0.28	75.11	5/10/91	ND	NA	5/20/91	1.94	73.45	5/30/91	1.44	73.95
G28S	79	69	DR	4/25/91	77.86	5/6/91	0.51	77.35	5/10/91	ND	NA	5/20/91	0.97	76.89	5/30/91	1.22	76.64
G29S	87	72	DR	4/25/91	96.36	5/6/91	0.00	96.36	5/10/91	0.00	96.36	5/20/91	-0.00	96.36	5/30/91	-0.00	96.36
G31D	64	49	SHB	4/25/91	90.84	5/6/91	0.70	90.14	5/10/91	0.83	90.01	5/20/91	1.39	89.45	5/30/91	1.61	89.23
G31S	80	70	DR	4/25/91	92.59	5/6/91	0.32	92.27	5/10/91	0.34	92.25	5/20/91	0.81	91.77	5/30/91	1.00	91.58
G34D	67	57	SHB	4/25/91	81.92	5/6/91	-0.19	82.11	5/10/91	-0.10	82.02	5/20/91	5.73	76.19	5/30/91	1.41	80.51
G34S	82	72	DR	4/25/91	83.55	5/6/91	-0.53	84.09	5/10/91	-0.44	83.99	5/20/91	7.02	76.53	5/30/91	1.60	81.95
G35D	65	55	SHB	4/25/91	81.80	5/6/91	-0.22	82.02	5/10/91	-0.16	81.96	5/20/91	5.77	76.03	5/30/91	1.39	80.41
G35DB	38	28	DPB	4/25/91	81.34	5/6/91	-0.17	81.51	5/10/91	-0.04	81.38	5/20/91	3.05	75.43	5/30/91	1.29	80.05
G35S	81	71	DR	4/25/91	81.76	5/6/91	-0.40	82.16	5/10/91	1.61	80.15	5/20/91	3.47	78.29	5/30/91	1.53	80.23
G36D	51	41	SHB	4/25/91	72.06	5/6/91	2.61	69.45	5/10/91	3.02	69.04	5/20/91	6.47	65.59	5/30/91	4.88	67.18
G36DB	20	10	DPB	4/25/91	70.93	5/6/91	4.55	66.38	5/10/91	5.24	65.69	5/20/91	7.76	63.17	5/30/91	7.45	63.48
G36DB2	-115	-125	DPB	4/25/91	64.38	5/6/91	13.64	50.74	5/10/91	14.73	49.65	5/20/91	15.97	48.41	5/30/91	17.23	47.15
G36S	65	55	DR	4/25/91	73.40	5/6/91	0.73	72.67	5/10/91	0.83	72.57	5/20/91	4.31	69.08	5/30/91	1.94	71.46
RW1	85	65	DR/SHB	4/25/91	85.62	5/6/91	-0.06	85.68	5/10/91	0.01	85.61	5/20/91	13.33	72.29	5/30/91	1.55	84.07
RW2	81	61	DR/SHB	4/25/91	83.72	5/6/91	-0.11	83.83	5/10/91	-0.23	83.95	5/20/91	11.76	71.96	5/30/91	1.83	81.89
RW3	82	62	DR/SHB	4/25/91	82.84	5/6/91	-0.27	83.11	5/10/91	-0.21	83.05	5/20/91	12.99	69.85	5/30/91	2.52	80.32
RW4	72	21	SHB	4/25/91	81.52	5/6/91	-0.13	81.65	5/10/91	0.02	81.50	5/20/91	11.84	69.68	5/30/91	1.35	80.17

TABLE 3.1-1 (continued)

Well	Screen or Packed Interval		Geologic Unit **	Water Elevation* Start		After 5 Days of Unifirst pumping			Before Grace Pumping			Before End Grace Pumping			End of Pilot Test		
	TOS	BOS		Date	W. Elev.	Date	WLC***	Elev.*	Date	WLC	Elev.*	Date	WLC	Elev.*	Date	WLC	Elev.*
RW5	77	72	DR	4/25/91	82.45	5/6/91	-0.19	82.64	5/10/91	-0.22	82.87	5/20/91	9.56	72.89	5/30/91	1.72	80.73
RW6	82	62	DR/SHB	4/25/91	81.47	5/6/91	-0.15	81.62	5/10/91	-0.21	81.68	5/20/91	9.02	72.45	5/30/91	1.65	79.82
RW7	64	44	DR/SHB	4/25/91	73.82	5/6/91	0.58	73.24	5/10/91	0.71	73.11	5/20/91	7.27	66.55	5/30/91	1.94	71.88
RW8	64	44	DR/SHB	4/25/91	73.69	5/6/91	0.73	72.96	5/10/91	0.72	72.97	5/20/91	7.04	66.65	5/30/91	2.04	71.65
RW9	66	46	DR/SHB	4/25/91	73.33	5/6/91	1.06	72.27	5/10/91	1.03	72.30	5/20/91	8.39	64.94	5/30/91	2.52	70.81
RW10	66	46	DR/SHB	4/25/91	73.49	5/6/91	0.79	72.70	5/10/91	0.89	72.60	5/20/91	7.27	66.22	5/30/91	2.29	71.20
S5	50	-12	DR/SHB	4/25/91	50.08	5/6/91	0.13	49.95	5/10/91	0.14	49.94	5/20/91	0.38	49.70	5/30/91	0.50	49.58
S6	54	-36	DR/SHB	4/25/91	55.42	5/6/91	0.34	55.08	5/10/91	0.40	55.02	5/20/91	0.66	54.76	5/30/91	0.91	54.51
S8	41	-84	DR/SHB	4/25/91	44.22	5/6/91	0.29	43.93	5/10/91	0.31	43.91	5/20/91	0.80	43.72	5/30/91	0.61	43.61
S21	73	46	DR/SHB	4/25/91	60.20	5/6/91	1.07	59.13	5/10/91	1.45	58.75	5/20/91	2.34	57.86	5/30/91	3.05	57.14
S22	80	40	DR/SHB	4/25/91	75.36	5/6/91	0.29	75.07	5/10/91	0.40	74.96	5/20/91	5.58	69.78	5/30/91	9.77	65.59
S39	-35	-45	DR	4/25/91	44.33	5/6/91	0.25	44.08	5/10/91	0.27	44.06	5/20/91	0.45	43.88	5/30/91	0.57	43.76
S40	-26	-36	DR	4/25/91	43.98	5/6/91	0.23	43.75	5/10/91	0.30	43.68	5/20/91	0.47	43.51	5/30/91	0.57	43.41
S63D	44	34	SHB	4/25/91	59.03	5/6/91	0.78	58.25	5/10/91	1.01	58.02	5/20/91	1.84	57.19	5/30/91	2.40	56.63
S63S	58	48	DR	4/25/91	58.89	5/6/91	0.65	58.24	5/10/91	0.93	57.96	5/20/91	1.62	57.27	5/30/91	2.22	56.67
S64D	18	3	SHB	4/29/91	55.00	5/6/91	0.18	54.82	5/10/91	0.29	54.71	5/20/91	0.75	54.25	5/30/91	1.14	53.86
S64M	31	26	DR	4/29/91	55.09	5/6/91	0.12	54.97	5/10/91	0.23	54.86	5/20/91	0.69	54.40	5/30/91	1.06	54.03
S64S	48	43	DR	4/29/91	54.36	5/6/91	0.08	54.28	5/10/91	0.18	54.18	5/20/91	0.71	53.65	5/30/91	1.16	53.20
S65S	31	21	SHB	4/25/91	57.86	5/6/91	0.35	57.51	5/10/91	0.56	57.30	5/20/91	1.16	56.70	5/30/91	1.70	56.16
S65M	50	40	DR	4/25/91	57.84	5/6/91	0.37	57.47	5/10/91	0.58	57.26	5/20/91	1.18	56.66	5/30/91	1.72	56.12
RS65D	73	53	DR	4/25/91	56.57	5/6/91	0.29	56.28	5/10/91	0.39	56.18	5/20/91	0.92	55.65	5/30/91	1.42	55.15
S66	50	35	SHB	4/25/91	57.92	5/6/91	0.86	57.06	5/10/91	1.09	56.83	5/20/91	1.68	56.24	5/30/91	2.19	55.73
S67D	23	8	SHB	4/25/91	67.06	5/6/91	3.13	63.93	5/10/91	3.56	63.50	5/20/91	4.27	62.79	5/30/91	4.90	62.16
S67M	50	40	DR	4/25/91	69.63	5/6/91	0.40	69.23	5/10/91	0.57	69.06	5/20/91	1.01	68.62	5/30/91	1.46	68.17
S67S	59	49	DR	4/25/91	69.32	5/6/91	-0.09	69.41	5/10/91	0.04	69.28	5/20/91	0.44	68.88	5/30/91	0.90	68.42
S68D	-9	-59	DR	4/25/91	45.31	5/6/91	1.29	44.02	5/10/91	1.30	44.01	5/20/91	1.49	43.82	5/30/91	1.62	43.69
S68S	31	0	DR	4/25/91	44.29	5/6/91	0.29	44.00	5/10/91	0.27	44.02	5/20/91	0.49	43.80	5/30/91	0.62	43.67
S69D	35	20	SHB	4/25/91	60.89	5/6/91	1.06	59.83	5/10/91	1.43	59.46	5/20/91	2.11	58.78	5/30/91	2.76	58.13
S70D	2	-13	SHB	4/25/91	57.84	5/6/91	1.43	56.41	5/10/91	1.64	56.30	5/20/91	2.00	55.84	5/30/91	2.39	55.45
S70M	27	7	DR	4/25/91	57.41	5/6/91	0.08	57.33	5/10/91	0.14	57.27	5/20/91	0.43	56.98	5/30/91	0.74	56.67
S70S	54	39	SR	4/25/91	57.43	5/6/91	0.09	57.34	5/10/91	0.14	57.29	5/20/91	0.46	56.97	5/30/91	0.80	56.63
S71D	49	29	SHB	4/29/91	59.07	5/6/91	-0.74	59.81	5/10/91	-0.58	59.65	5/20/91	-0.10	59.17	5/30/91	0.43	58.64
S71S	60	55	DR	4/25/91	60.64	5/6/91	0.28	60.36	5/10/91	0.44	60.20	5/20/91	0.90	59.74	5/30/91	1.38	59.26
S72D	-72	-87	SHB	4/25/91	45.28	5/6/91	0.19	45.09	5/10/91	0.23	45.05	5/20/91	0.38	44.90	5/30/91	0.51	44.77
S72M	-4	-42	DR	4/25/91	45.23	5/6/91	0.22	45.01	5/10/91	0.23	45.00	5/20/91	0.43	44.80	5/30/91	0.52	44.71

TABLE 3.1-1 (continued)

Well	Screen or Packed Interval		Geologic Unit **	Water Elevation* Start		After 5 Days of Unifirst pumping			Before Grace Pumping			Before End Grace Pumping			End of Pilot Test		
	TOS	BOS		Date	W. Elev.	Date	WLC***	Elev.*	Date	WLC	Elev.*	Date	WLC	Elev.*	Date	WLC	Elev.*
S72S	17	-3	DR	4/25/91	45.18	5/8/91	0.14	45.04	5/10/91	0.17	45.01	5/20/91	0.31	44.87	5/30/91	0.45	44.73
S73S	42	17	DR	4/25/91	48.48	5/8/91	0.11	48.37	5/10/91	0.16	48.32	5/20/91	0.34	48.14	5/30/91	0.47	48.01
S73D	12	-4	SHB	4/25/91	48.44	5/8/91	0.16	48.28	5/10/91	0.17	48.27	5/20/91	0.35	48.09	5/30/91	0.50	47.94
S74D	-25	-40	SHB	4/25/91	47.47	5/8/91	0.22	47.25	5/10/91	0.24	47.23	5/20/91	0.44	47.03	5/30/91	0.57	46.90
S74S	40	-10	DR	4/25/91	47.45	5/8/91	0.21	47.24	5/10/91	0.22	47.23	5/20/91	0.44	47.01	5/30/91	0.57	46.88
S81D	-13	-28	SHB	4/25/91	49.36	5/8/91	-0.75	50.11	5/10/91	0.23	49.13	5/20/91	0.47	48.89	5/30/91	0.59	48.77
S81M	20	5	DR	4/25/91	51.69	5/5/91	0.15	51.54	5/10/91	0.19	51.50	5/20/91	0.44	51.25	5/30/91	0.63	51.06
S81S	44	34	DR	4/25/91	52.74	5/8/91	0.08	52.66	5/10/91	0.17	52.57	5/20/91	0.43	52.31	5/30/91	0.65	52.09
S82	32	22	DR	4/25/91	49.52	5/8/91	0.19	49.33	5/10/91	0.20	49.32	5/20/91	0.36	49.16	5/30/91	0.56	48.96
S84D	-27	-32	DR	4/25/91	45.30	5/8/91	0.39	44.91	5/10/91	0.41	44.89	5/20/91	0.64	44.66	5/30/91	0.80	44.50
S84M	6	1	DR	4/25/91	44.48	5/8/91	0.39	44.09	5/10/91	0.42	44.06	5/20/91	0.64	43.84	5/30/91	0.81	43.67
S84S	33	28	DR	4/25/91	44.47	5/8/91	0.40	44.07	5/10/91	0.42	44.05	5/20/91	0.68	43.79	5/30/91	0.81	43.66
S85M	-19	-25	DR/SHB	4/25/91	44.86	5/8/91	0.24	44.62	5/10/91	0.25	44.61	5/20/91	0.44	44.42	5/30/91	0.56	44.30
S85S	26	16	DR	4/25/91	44.69	5/8/91	0.21	44.48	5/10/91	0.23	44.46	5/20/91	0.39	44.30	5/30/91	0.52	44.17
S86D	-4	-9	DR	4/25/91	43.94	5/8/91	0.25	43.69	5/10/91	0.30	43.64	5/20/91	0.42	43.52	5/30/91	0.59	43.35
S86S	18	13	DR	4/25/91	43.95	5/8/91	0.25	43.70	5/10/91	0.27	43.68	5/20/91	0.38	43.57	5/30/91	0.59	43.36
S87D	-30	-34	DR	4/25/91	44.51	5/8/91	0.26	44.25	5/10/91	0.28	44.23	5/20/91	0.44	44.07	5/30/91	0.58	43.93
S87M	10	6	DR	4/25/91	44.49	5/8/91	0.22	44.27	5/10/91	0.23	44.26	5/20/91	0.39	44.10	5/30/91	0.53	43.96
S87S	39	35	DR	4/25/91	44.40	5/8/91	0.18	44.22	5/10/91	0.20	44.20	5/20/91	0.37	44.03	5/30/91	0.51	43.89
S88D	-32	-36	DR	4/25/91	44.22	5/8/91	0.19	44.03	5/10/91	0.19	44.03	5/20/91	0.34	43.88	5/30/91	0.45	43.77
S88M	8	4	DR	4/25/91	44.21	5/8/91	0.17	44.04	5/10/91	0.17	44.04	5/20/91	0.31	43.90	5/30/91	0.41	43.80
S88S	38	34	DR	4/25/91	44.22	5/8/91	0.17	44.05	5/10/91	0.18	44.04	5/20/91	0.31	43.91	5/30/91	0.41	43.81
S89D	-72	-76	DR	4/25/91	44.30	5/8/91	0.21	44.09	5/10/91	0.22	44.08	5/20/91	0.39	43.91	5/30/91	0.49	43.81
S89M	-4	-8	DR	4/25/91	44.16	5/8/91	0.49	43.67	5/10/91	0.51	43.65	5/20/91	0.36	43.80	5/30/91	0.47	43.69
S89S	16	12	DR	4/25/91	44.13	5/8/91	0.17	43.96	5/10/91	0.20	43.93	5/20/91	0.34	43.79	5/30/91	0.44	43.69
S90D	-14	-27	DR/SHB	4/25/91	44.45	5/8/91	0.27	44.16	5/10/91	0.28	44.17	5/20/91	0.46	43.97	5/30/91	0.61	43.84
S90M	13	7	DR	4/25/91	44.49	5/8/91	0.27	44.22	5/10/91	0.29	44.20	5/20/91	0.49	44.00	5/30/91	0.63	43.86
S90S	41	37	DR	4/25/91	44.71	5/8/91	0.35	44.36	5/10/91	0.37	44.34	5/20/91	0.68	44.03	5/30/91	0.86	43.85
S91D	-32	-36	DR	4/25/91	44.18	5/8/91	0.27	43.91	5/10/91	0.28	43.90	5/20/91	0.47	43.71	5/30/91	0.58	43.60
S91M	9	5	DR	4/25/91	43.91	5/8/91	0.23	43.68	5/10/91	0.23	43.68	5/20/91	0.42	43.49	5/30/91	0.53	43.38
S91S	39	35	DR	4/25/91	44.29	5/8/91	0.27	44.02	5/10/91	0.29	44.00	5/20/91	0.47	43.82	5/30/91	0.60	43.69
S93D	-33	-37	DR	4/25/91	43.89	5/8/91	0.20	43.69	5/10/91	0.26	43.63	5/20/91	0.43	43.46	5/30/91	0.50	43.39
S93M	3	-2	DR	4/25/91	43.56	5/8/91	0.14	43.42	5/10/91	0.19	43.37	5/20/91	0.27	43.29	5/30/91	0.31	43.24
S93S	32	26	DR	4/25/91	43.49	5/8/91	0.15	43.34	5/10/91	0.16	43.33	5/20/91	0.28	43.21	5/30/91	0.29	43.20
S94D	-29	-34	DR	4/25/91	44.08	5/8/91	0.29	43.79	5/10/91	0.32	43.76	5/20/91	0.53	43.55	5/30/91	0.62	43.46

TABLE 3.1-1 (continued)

Well	Screen or Packed Interval		Geologic Unit **	Water Elevation* Start		After 5 Days of Unifirst pumping			Before Grace Pumping			Before End Grace Pumping			End of Pilot Test		
	TOS	BOS		Date	W. Elev.	Date	WLC***	Elev.*	Date	WLC	Elev.*	Date	WLC	Elev.*	Date	WLC	Elev.*
S94M	10	6	DR	4/25/91	44.07	5/6/91	0.28	43.79	5/10/91	0.29	43.78	5/20/91	0.56	43.50	5/30/91	0.61	43.45
S94S	35	31	DR	4/25/91	44.20	5/6/91	0.34	43.86	5/10/91	0.39	43.81	5/20/91	0.66	43.54	5/30/91	0.81	43.39
S95D	-33	-37	DR	4/25/91	43.77	5/6/91	0.19	43.58	5/10/91	0.25	43.52	5/20/91	0.39	43.38	5/30/91	0.49	43.28
S95M	7	3	DR	4/25/91	43.64	5/6/91	0.15	43.49	5/10/91	0.20	43.44	5/20/91	0.23	43.41	5/30/91	0.44	43.20
S95S	35	28	DR	4/25/91	43.34	5/6/91	0.12	43.22	5/10/91	0.17	43.17	5/20/91	0.25	43.09	5/30/91	0.38	42.96
S97D	7	5	SHB	4/25/91	45.47	5/6/91	0.35	45.12	5/10/91	0.38	45.09	5/20/91	0.61	44.86	5/30/91	0.78	44.69
S97M	26	22	DR	4/25/91	45.27	5/6/91	0.37	44.90	5/10/91	0.41	44.86	5/20/91	0.64	44.63	5/30/91	0.80	44.47
S97S	41	34	DR	4/25/91	45.40	5/6/91	0.38	45.02	5/10/91	0.41	44.99	5/20/91	0.68	44.72	5/30/91	0.86	44.54
NEP-A	1	-539	BR	4/25/91	55.52	5/6/91	1.29	54.23	5/10/91	1.46	54.06	5/20/91	1.86	53.66	5/30/91	2.15	53.37
NEP-B	18	-540	BR	4/25/91	52.26	5/6/91	0.45	51.81	5/10/91	0.56	51.66	5/20/91	1.00	51.26	5/30/91	1.29	50.97
NEP-1	16	-297	BR	4/25/91	50.38	5/6/91	0.31	50.07	5/10/91	0.43	49.95	5/20/91	0.79	49.59	5/30/91	1.00	49.38
NEP-2	33	-440	BR	4/25/91	48.20	5/6/91	0.55	47.65	5/10/91	0.69	47.51	5/20/91	0.84	47.36	5/30/91	1.29	46.91
NEP-3	15	-879	BR	4/25/91	49.21	5/6/91	0.04	49.17	5/10/91	0.33	48.88	5/20/91	0.64	48.57	5/30/91	0.91	48.30
NEP-101	56	48	DR	4/25/91	55.12	5/6/91	0.24	54.88	5/10/91	0.32	54.80	5/20/91	0.71	54.41	5/30/91	1.02	54.10
NEP-101B	35	30	BR	4/25/91	54.45	5/6/91	0.32	54.13	5/10/91	0.39	54.06	5/20/91	0.81	53.63	5/30/91	1.12	53.33
NEP-102	52	45	DR	4/25/91	52.48	5/6/91	-3.91	56.39	5/10/91	-3.86	56.34	5/20/91	-3.63	56.11	5/30/91	-3.45	55.93
NEP-102B	21	16	BR	4/25/91	55.58	5/6/91	0.22	55.36	5/10/91	0.37	55.21	5/20/91	0.75	54.83	5/30/91	1.05	54.53
NEP-103	53	48	DR	4/25/91	51.87	5/6/91	0.60	51.27	5/10/91	0.56	51.31	5/20/91	1.15	50.72	5/30/91	1.17	50.70
NEP-103B	39	32	BR	4/25/91	52.34	5/6/91	0.47	51.87	5/10/91	0.60	51.74	5/20/91	1.24	51.10	5/30/91	1.63	50.71
NEP-104	49	42	DR	4/25/91	51.97	5/6/91	0.40	51.57	5/10/91	0.48	51.49	5/20/91	0.93	51.04	5/30/91	1.22	50.75
NEP-104B	26	18	BR	4/25/91	50.86	5/6/91	0.45	50.41	5/10/91	0.53	50.33	5/20/91	0.99	49.86	5/30/91	1.26	49.59
NEP-105B	45	38	BR	4/25/91	50.15	5/6/91	-0.23	50.38	5/10/91	-0.04	50.19	5/20/91	1.58	48.57	5/30/91	3.18	46.97
NEP-106B	17	10	BR	4/25/91	44.54	5/6/91	0.35	44.19	5/10/91	0.40	44.14	5/20/91	0.59	43.95	5/30/91	0.78	43.76
NEP-107B	17	10	BR	4/25/91	54.65	5/6/91	0.89	53.76	5/10/91	1.07	53.58	5/20/91	1.43	53.22	5/30/91	1.76	52.89
NEP-108A	41	31	DR	4/25/91	55.03	5/6/91	0.29	54.74	5/10/91	0.32	54.71	5/20/91	0.67	54.35	5/30/91	0.96	54.06
NEP-108B	11	6	BR	4/25/91	55.85	5/6/91	0.65	55.20	5/10/91	0.79	55.06	5/20/91	1.20	54.65	5/30/91	1.57	54.28
NEP-109	52	42	DR	4/25/91	52.70	5/6/91	0.41	52.29	5/10/91	0.52	52.18	5/20/91	1.16	51.54	5/30/91	1.50	51.20
NEP-110B	51	-40	BR	4/25/91	49.71	5/6/91	0.64	49.07	5/10/91	-2.03	51.74	5/20/91	2.06	47.65	5/30/91	3.04	46.67
EPA-1	38	28	DR	4/25/91	44.69	5/6/91	0.44	44.25	5/10/91	0.45	44.24	5/20/91	0.72	43.97	5/30/91	0.87	43.82
EPA-2	41	31	DR	4/25/91	48.27	5/6/91	0.26	48.01	5/10/91	0.31	47.96	5/20/91	0.34	47.93	5/30/91	1.03	47.24
EPA-3	45	35	DR	4/25/91	52.10	5/6/91	0.05	52.05	5/10/91	0.11	51.99	5/20/91	0.58	51.52	5/30/91	0.81	51.29

TABLE 3.1-1 (continued)

NOTES

* All elevations are in feet above National Vertical Geodetic Datum.
TOS indicates top of screen, BOS indicates bottom of screen.

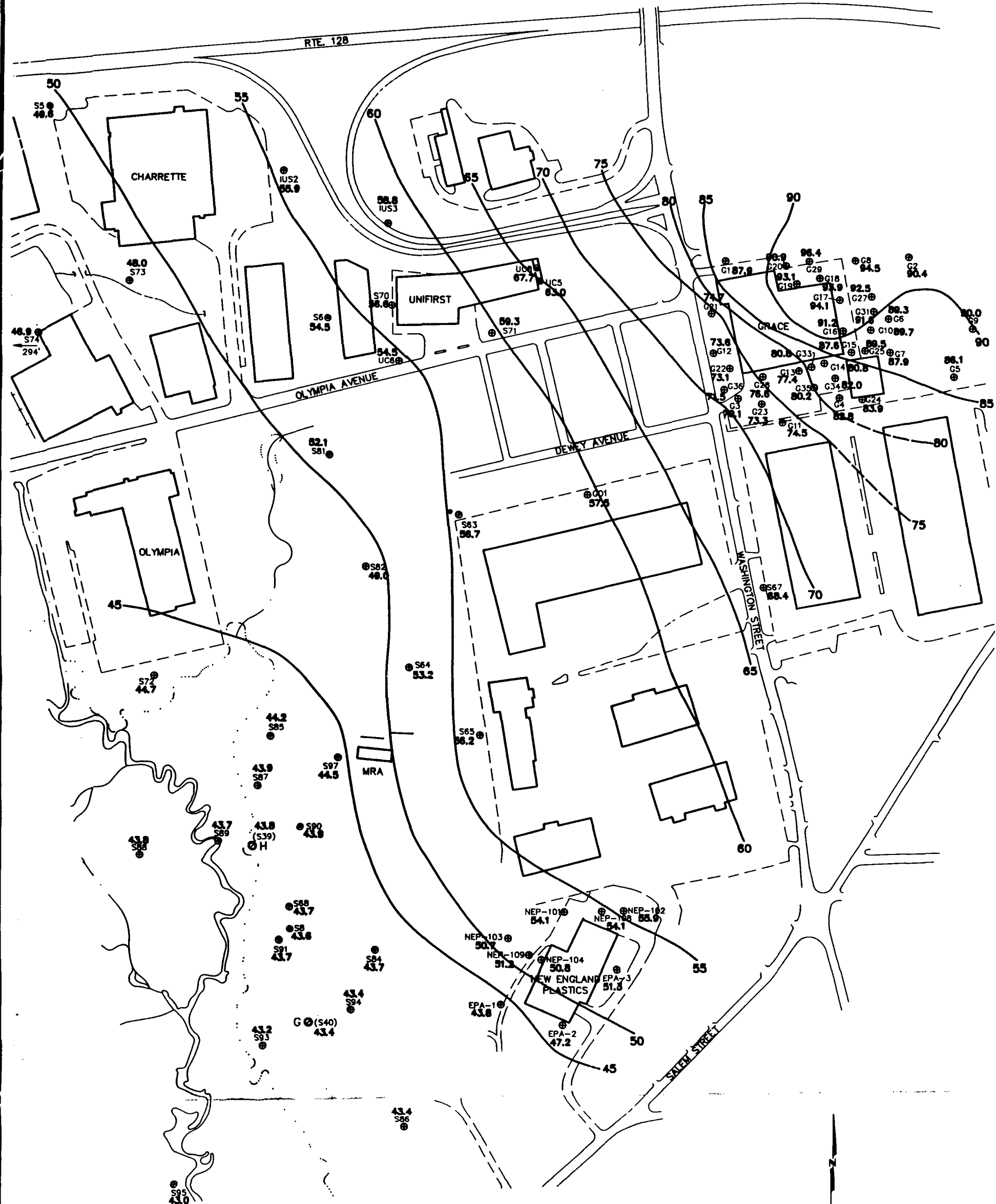
** DR is screened in unconsolidated glacial drift.
SHB indicates that the well is screened in shallow bedrock.
DPB indicates that the well is screened in deep bedrock.
DR/SHB indicates that the well is screened in drift and shallow bedrock.
BR indicates that the well is screened in bedrock at an unknown depth.

*** WLC= Water level change in feet since April 25, 1991. All other water level data are also in feet.

NM = Not Measured

ND = Not measured before Grace pumping began.

NA = Elevation not calculated.



EXPLANATION

- G1 @ 88.5 MONITORING WELL SCREENED IN UNCONSOLIDATED DEPOSITS AND WATER LEVEL ELEVATIONS ON 5/30/91 ROUNDED TO THE TENTH
- MONITORING WELL SCREENED IN BEDROCK AND UNCONSOLIDATED DEPOSITS
- ABANDONED WATER WELL SCREENED IN UNCONSOLIDATED DEPOSITS
- 70 — LINE OF EQUAL WATER LEVEL ELEVATION, FIVE FOOT CONTOUR INTERVAL

NOTE: ALL WATER LEVEL ELEVATIONS ARE FROM S (SHALLOW) WELLS

300 0 300

SCALE IN FEET

Remedial Design
of the Northeast Quadrant
Wells G & H Site
Woburn, MA

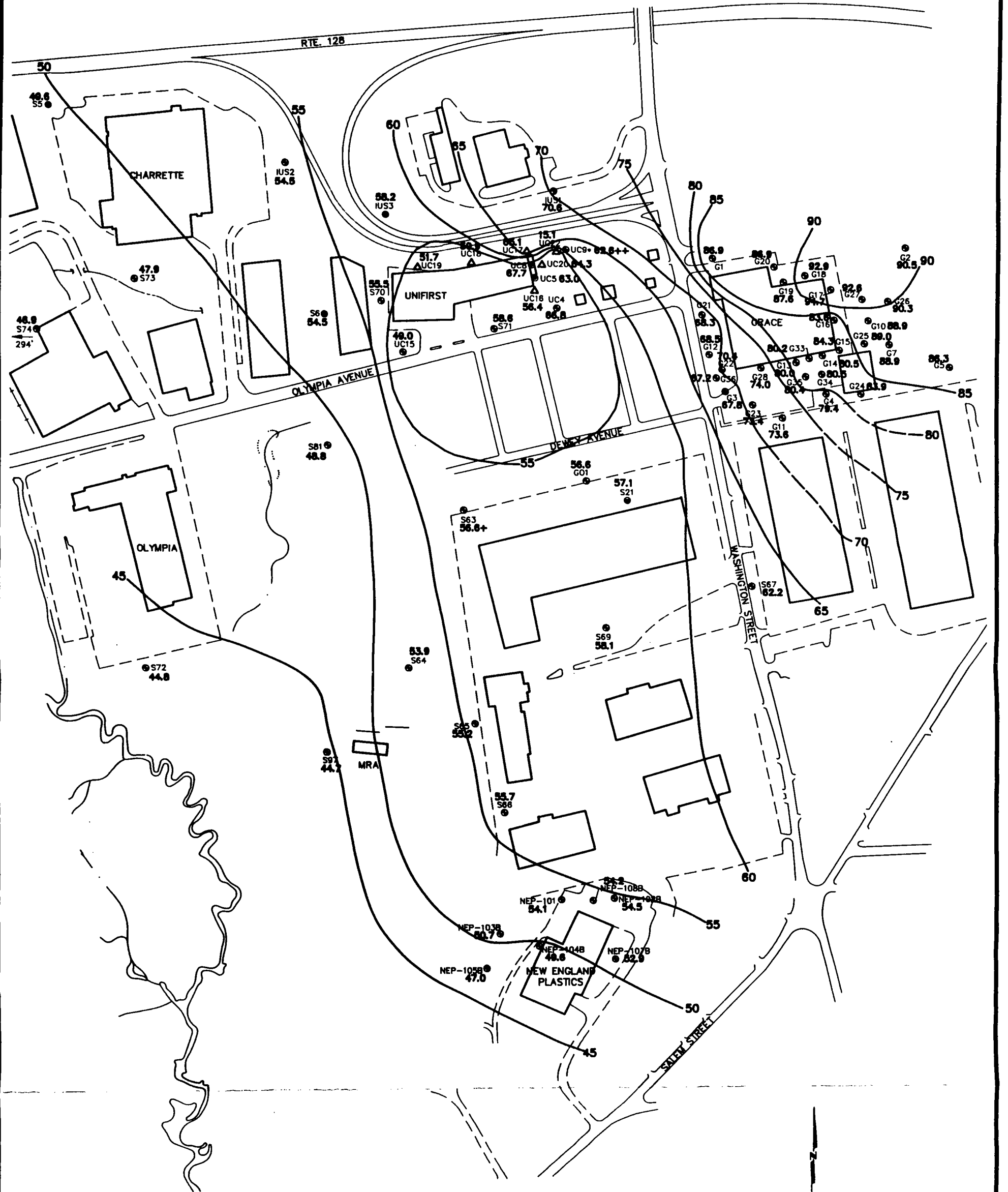
DRAFT

FIGURE 3.1-1

Estimated Potentiometric Surface of
Unconsolidated Deposits on Day 30 of Pumping

Prepared by ENSR Consulting and Engineering

MAP SOURCE: 1966 TOPOGRAPHIC MAP FOR PLANNING BOARD, CITY OF WOBURN, MASSACHUSETTS, LOCKWOOD, KESSLER & BARTLETT, INC., INCLUDING THE MODIFICATIONS MADE BY THE U.S. GEOLOGICAL SURVEY AND CONTAINED IN A 1987 U.S. GEOLOGICAL SURVEY WATER RESOURCES INVESTIGATIONS REPORT 87-4100 TITLED "AREA OF INFLUENCE AND ZONE OF CONTRIBUTION TO SUPERFUND-SITE WELLS G AND H, WOBURN, MASSACHUSETTS".



EXPLANATION

- G1 @ 88.8 MONITORING WELL SCREENED IN SHALLOW BEDROCK AND WATER LEVEL ELEVATION ON 5/30/91 ROUNDED TO THE TENTH
- MONITORING WELL SCREENED IN BEDROCK AND UNCONSOLIDATED DEPOSITS
- 70 — LINE OF EQUAL WATER LEVEL ELEVATION, FIVE FOOT CONTOUR INTERVAL
- ▲ 6-INCH WELL OPEN IN ROCK; UC22 IS AN 8-INCH WELL
- * ASTERISK INDICATES MULTIPOINT WELLS (e.g. UC10*)
- + WATER LEVEL MEASURED ON 5/29/91
- ++ WATER LEVEL MEASURED ON 5/24/91

NOTE: —THIS MAP IS CONSIDERED ESTIMATED DUE TO THE 55 FOOT LINE OF EQUAL WATER LEVEL ELEVATION

300 0 300

SCALE IN FEET

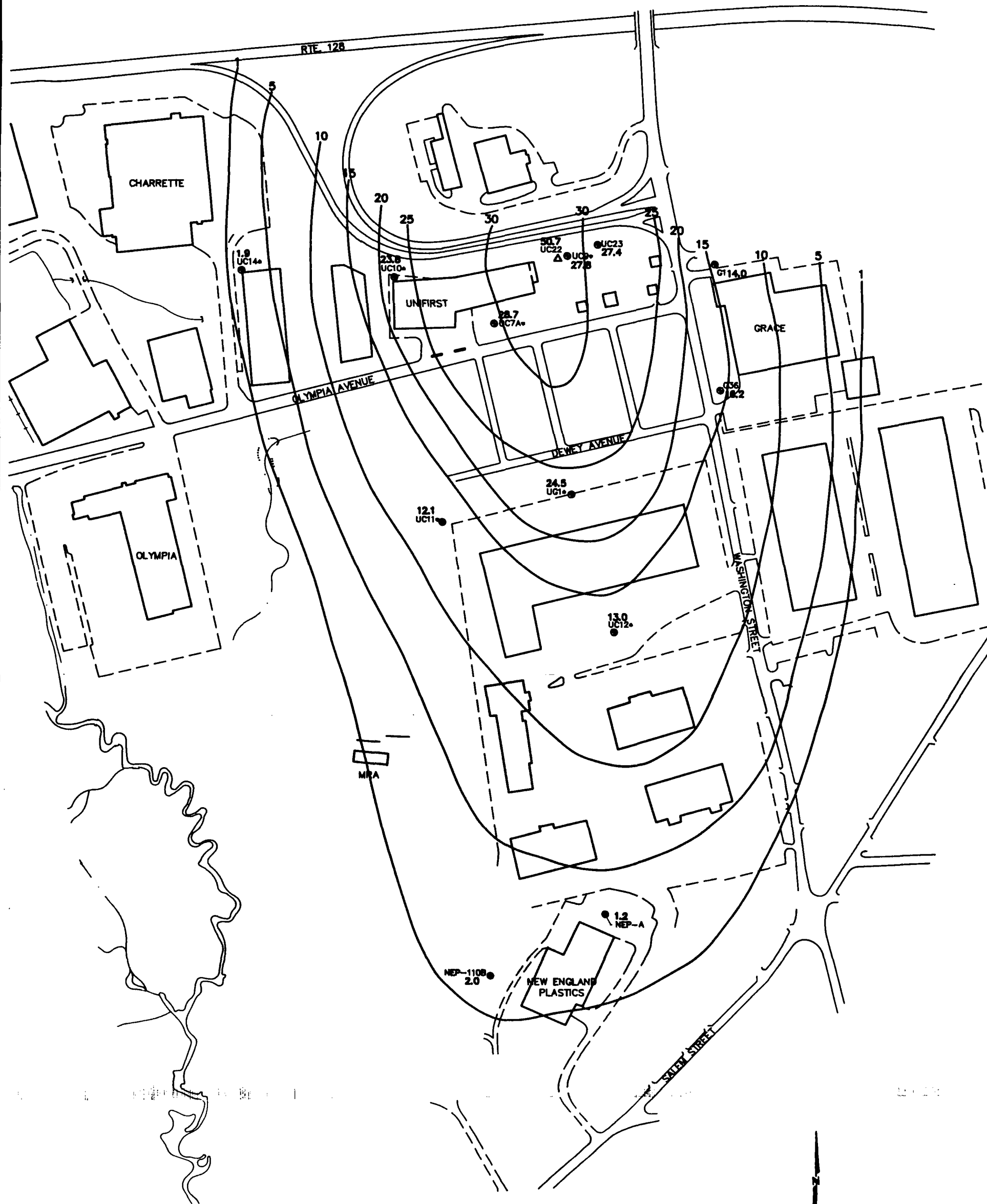
DRAFT

Remedial Design
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Wells G & H Site
Woburn, MA

FIGURE 3.1-2

Estimated Potentiometric Surface of
Shallow Bedrock on Day 30 of Pumping

Prepared by ENSR and Consulting and Engineering

**EXPLANATION**

- G1@14 MONITORING WELL SCREENED IN DEEP BEDROCK AND MAXIMUM
DRAWDOWN (ft) MEASURED 5/30/91 ROUNDED TO THE TENTH
- 70 — LINE OF EQUAL DRAWDOWN FIVE FOOT CONTOUR INTERVAL
- ▲ UC22 IS AN 8-INCH WELL OPEN IN ROCK
- ASTERISK INDICATES MULTIPOINT WELLS (e.g. UC10*)

NOTE: — THE MAXIMUM DRAWDOWN VALUE DEPICTED ONE FOOT LESS THAN THE ACTUAL MEASUREMENT

— ONLY WELLS WITH THE GREATEST RESPONSE TO PUMPING ARE PRESENTED ALONG WITH
WELLS UC14, NEP-A AND NEP-110B FOR BOUNDARY DEFINITION

300 0 300

SCALE IN FEET

DRAFT**SCALE IN FEET**

Remedial Design
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Wells G & H Site
Woburn, MA

FIGURE 3.1-3

Water Level Contours for Bedrock Wells Showing
the Greatest Response to Pumping on Day 30

Prepared by ENSR Consulting and Engineering

declines in deeper wells were greater than 20 feet, such as well UG1, which is approximately 750 feet from the pumping well UC22.

Based on the wells with the greatest water level response to pumping, Figure 3.1-4 presents the largest area in the bedrock of drawdown or the largest areal zone of influence from UC22. All the well locations presented in Figure 3.1-4 with the exception of NEP-110B, NEP-A and UC14 are considered wells which had a significantly greater response than other wells measured during the pumping test.

Figure 2.3-14 shows the locations of cross sections A-A' through H-H'. These cross sections are presented in Figures 3.1-5 through 3.1-12 to represent the water elevations and potentiometric levels before pumping began and on the final day of pumping. Cross section D-D' shows that the greatest measured depth of response to pumping was monitoring point UG1-2 which is 480 feet below ground surface. UG1-2 is the deepest operable monitoring point in the Northeast Quadrant, and approximately 16 feet of drawdown was recorded at this location. Given the irregular nature of the vertical response to pumping in a heterogeneous fracture system, it is not possible to illustrate the long term capture zone in cross section.

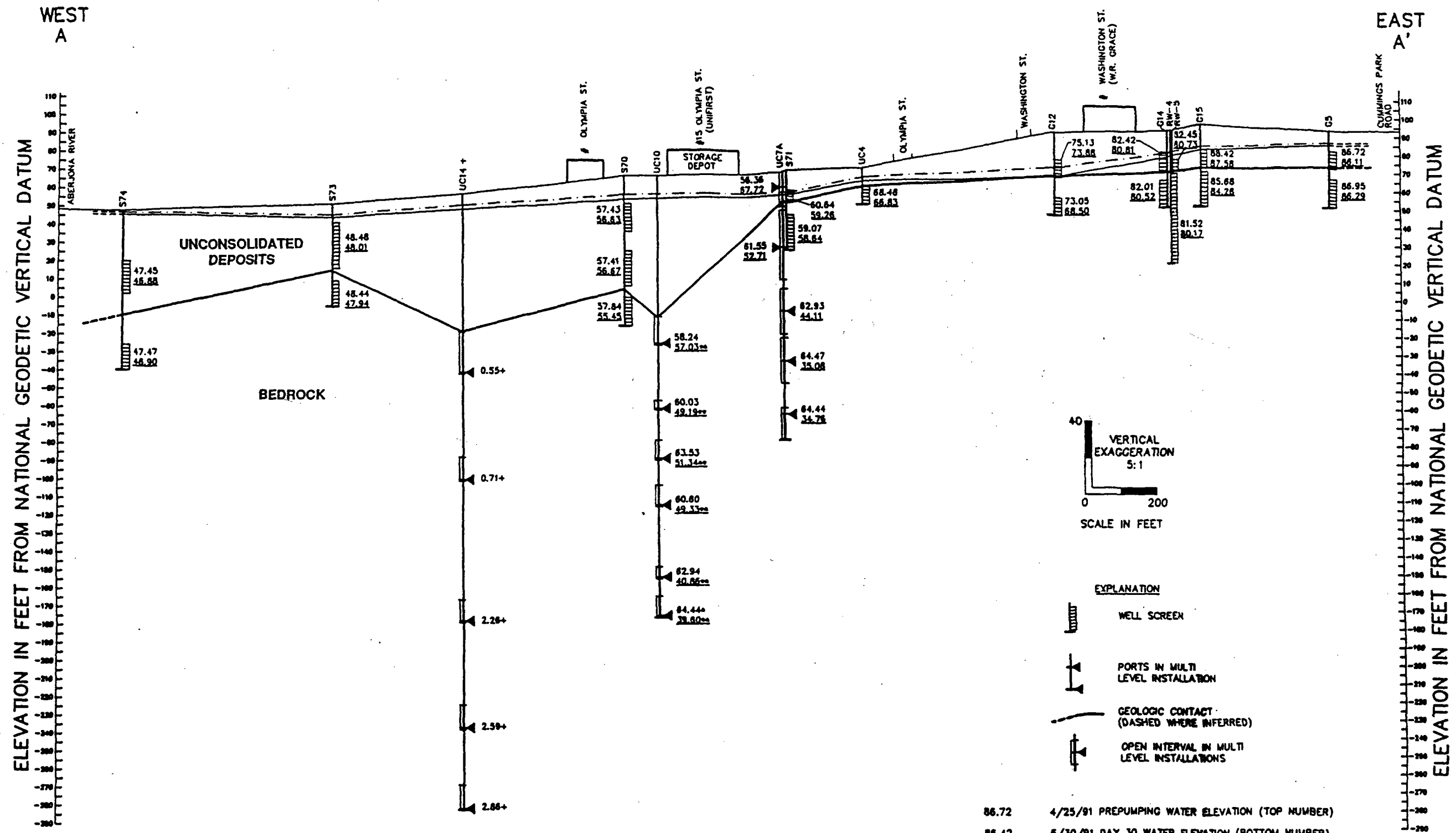
3.1.3 Zone of Capture of UC22 Pumping

Figure 3.1-13 shows the zone of capture of UC22 pumping based on the wells with the greatest water level response described in the previous section. Although the actual captured area upgradient of the shaded area in the figure is probably larger, the defined zone of capture was limited to those areas in which data were available.

Although equipotential lines cannot be completed on the cross sections in order to define the vertical zone of capture, the water-level elevation data presented on the cross sections show potential for ground-water flow to UC22 from as deep as 480 feet at UG1-2.

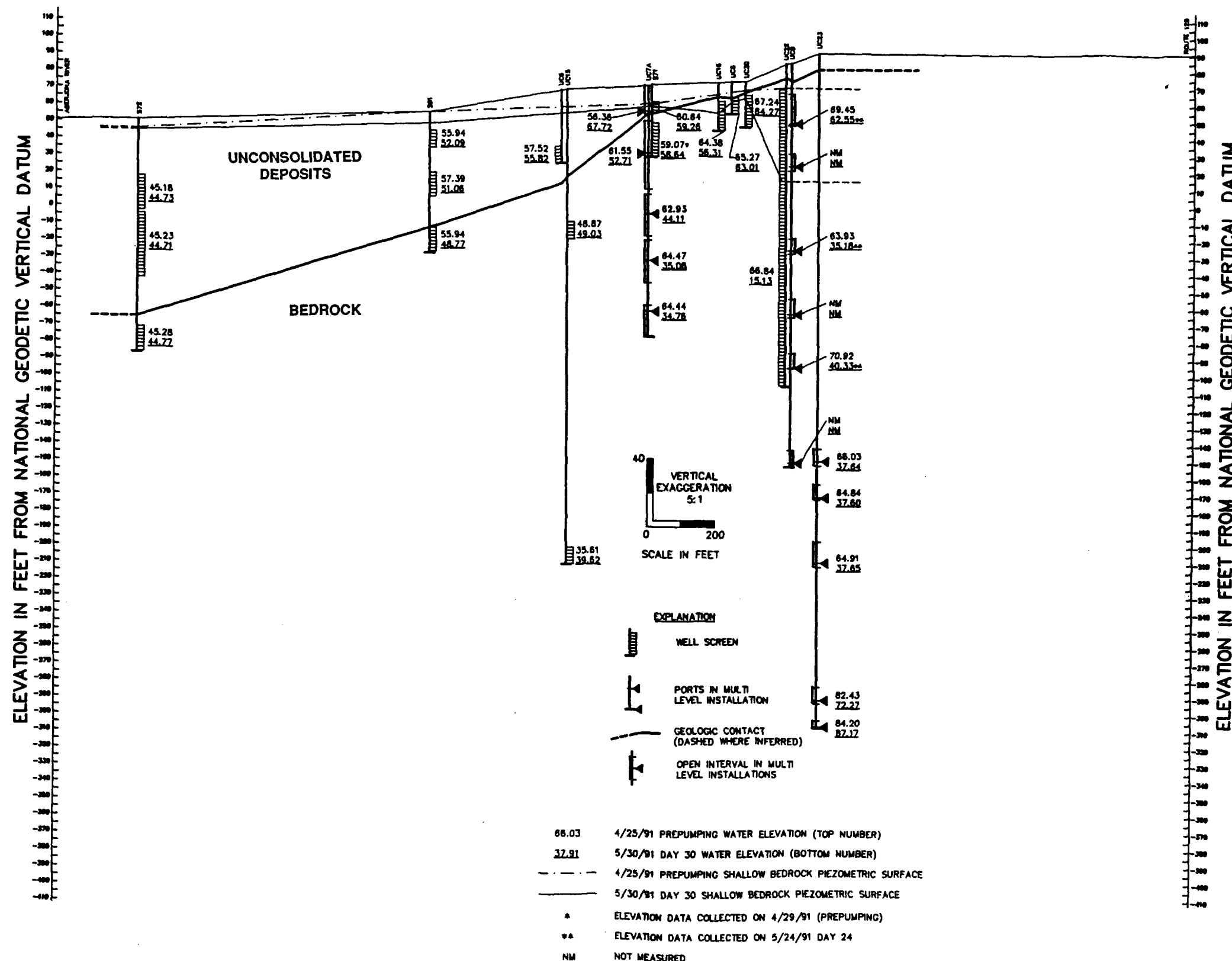
3.1.4 Contaminant Mass Removal

During the 30-day pilot test, the contaminant mass removal rate from the pumping well UC22 ranged from approximately 0.07 to 2.75 pounds per day. This mass removal rate is based on an approximate average pumping rate of 50 gallons per minute and the sum of the three principal compounds detected, tetrachloroethene, trichloroethene and 1,1,1-trichloroethane. Tables 3.1-2 and 3.1-3 present the daily concentrations detected in the influent water to the treatment system. The laboratory data was utilized to determine the range of tetrachloroethene concentrations, and the A+RT Field Organics Analyzer System was utilized to determine the



SOUTHEAST
B

NORTHEAST
B'



DRAFT

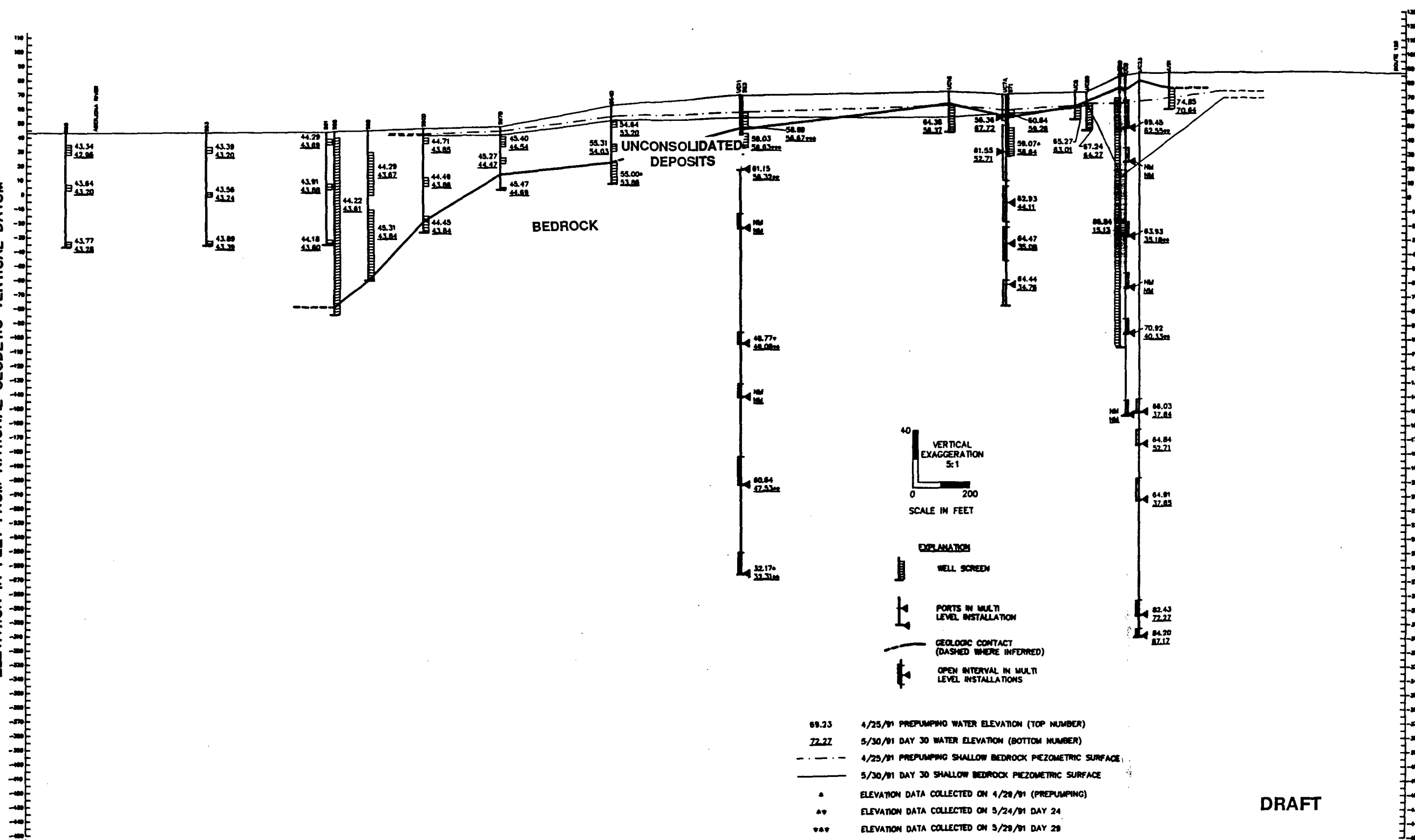
FIGURE 3.1-6
Cross-Section B-B'
Estimated Potentiometric
Surface of Shallow
Bedrock Before and On
Day 30 of Pumping

SOUTH
SOUTHWEST
C

NORTH
NORTHEAST
C'

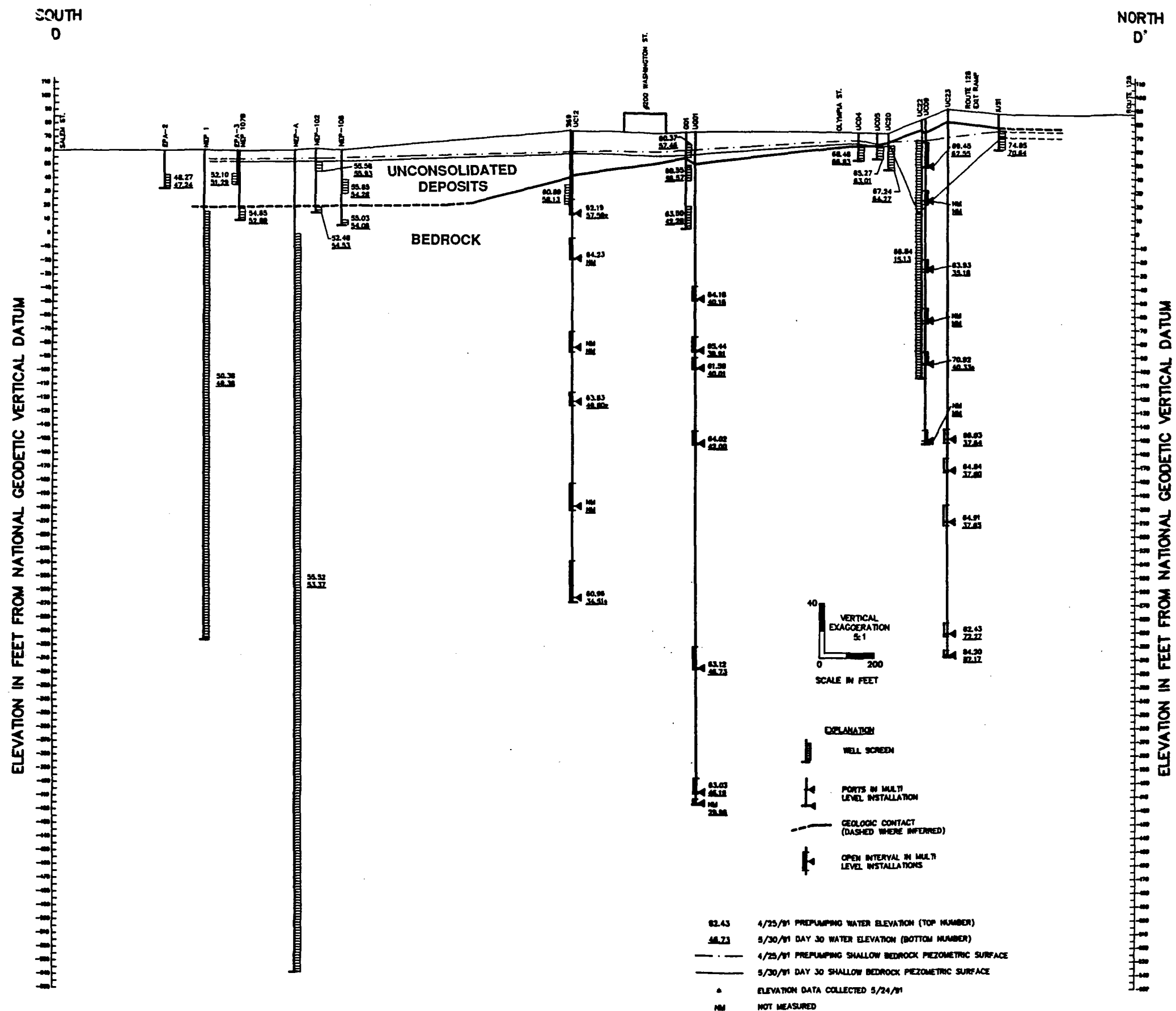
ELEVATION IN FEET FROM NATIONAL GEODETIC VERTICAL DATUM

ELEVATION IN FEET FROM NATIONAL GEODETIC VERTICAL DATUM



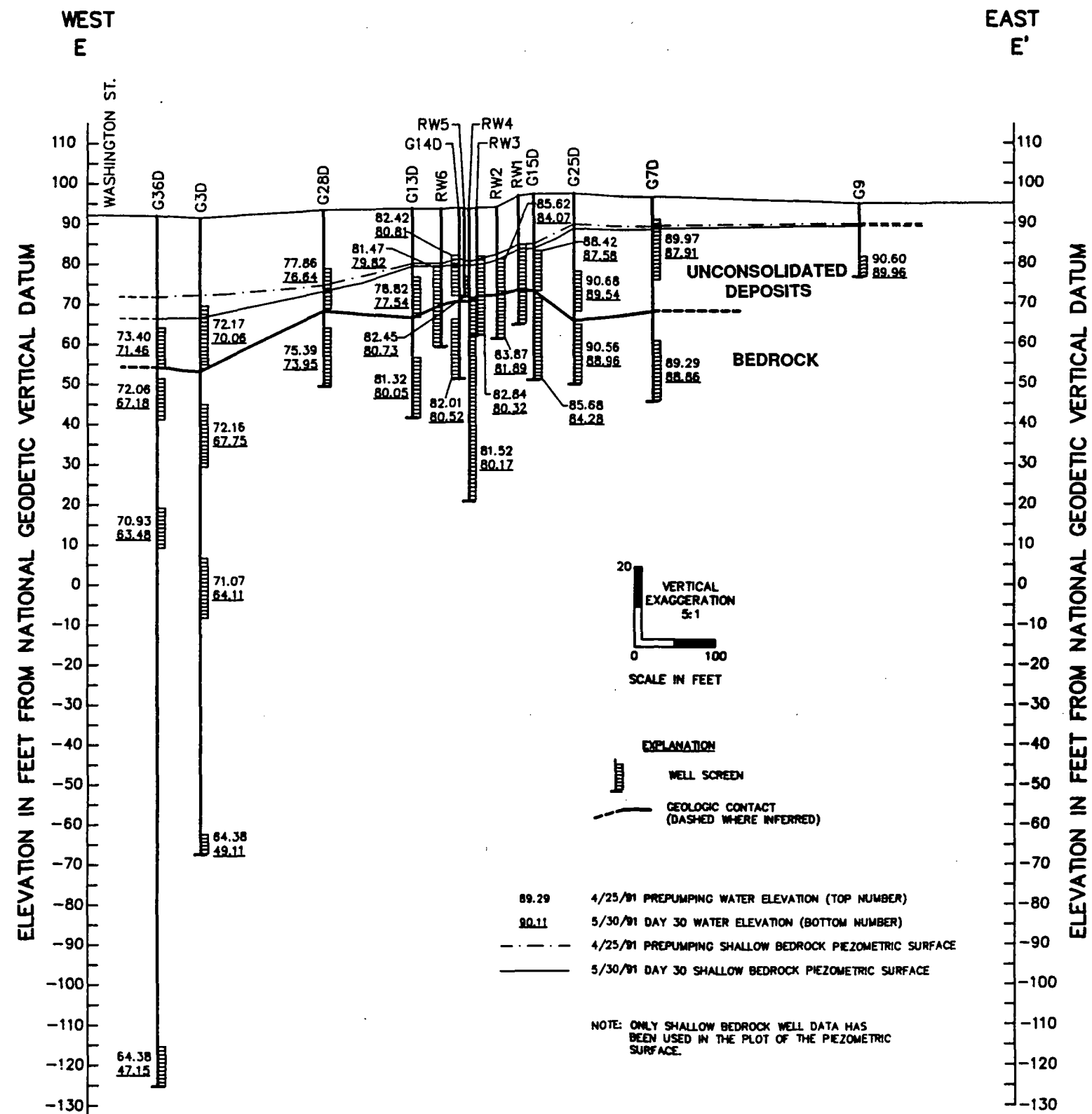
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FIGURE 3.1-7
Cross-Section C-C'
Estimated Potentiometric Surface of Shallow
Bedrock Before and On Day 30 of Pumping



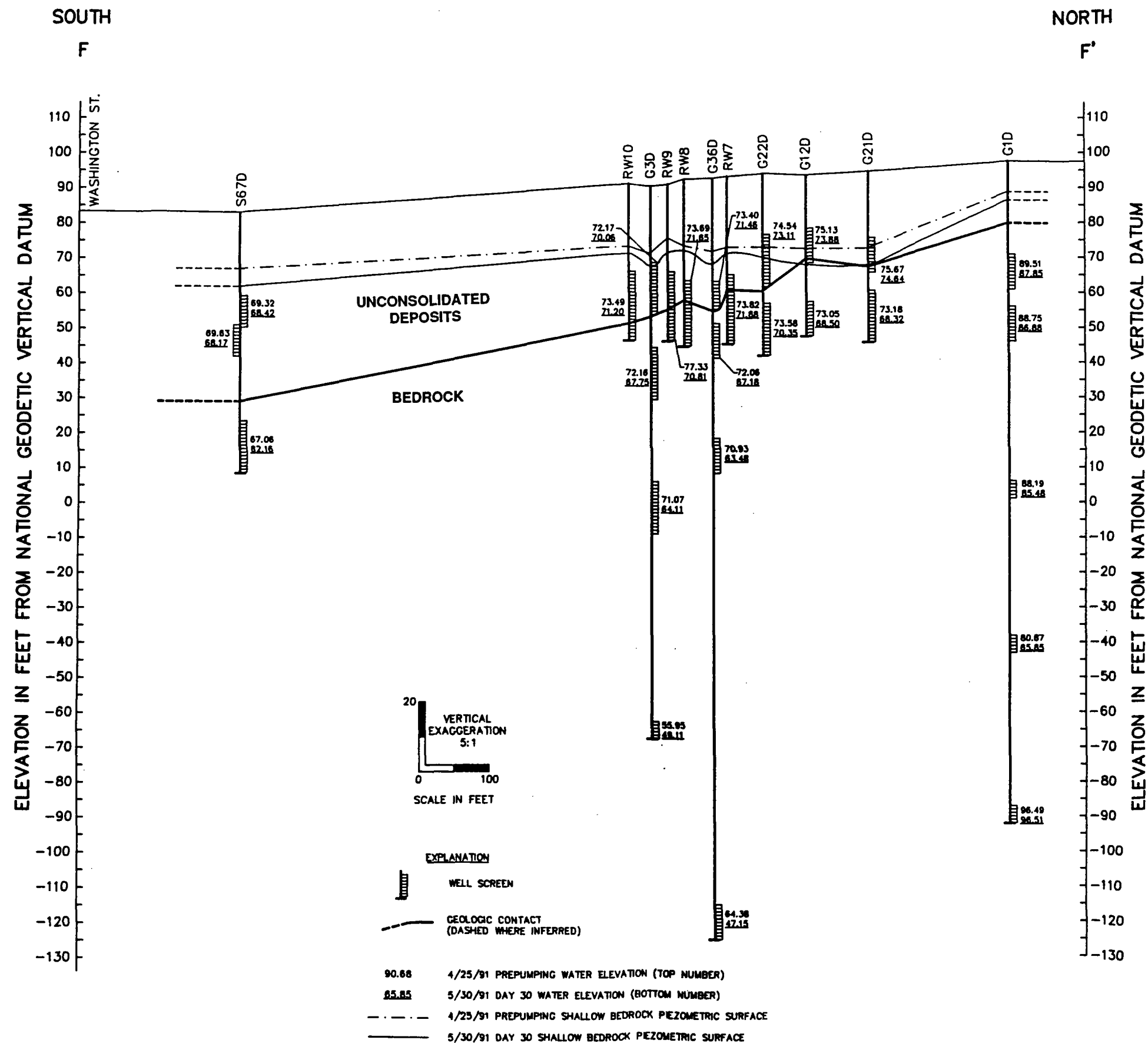
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FIGURE 3.1-8
Cross-Section D-D'
Estimated Potentiometric Surface of Shallow
Bedrock Before and On Day 30 of Pumping



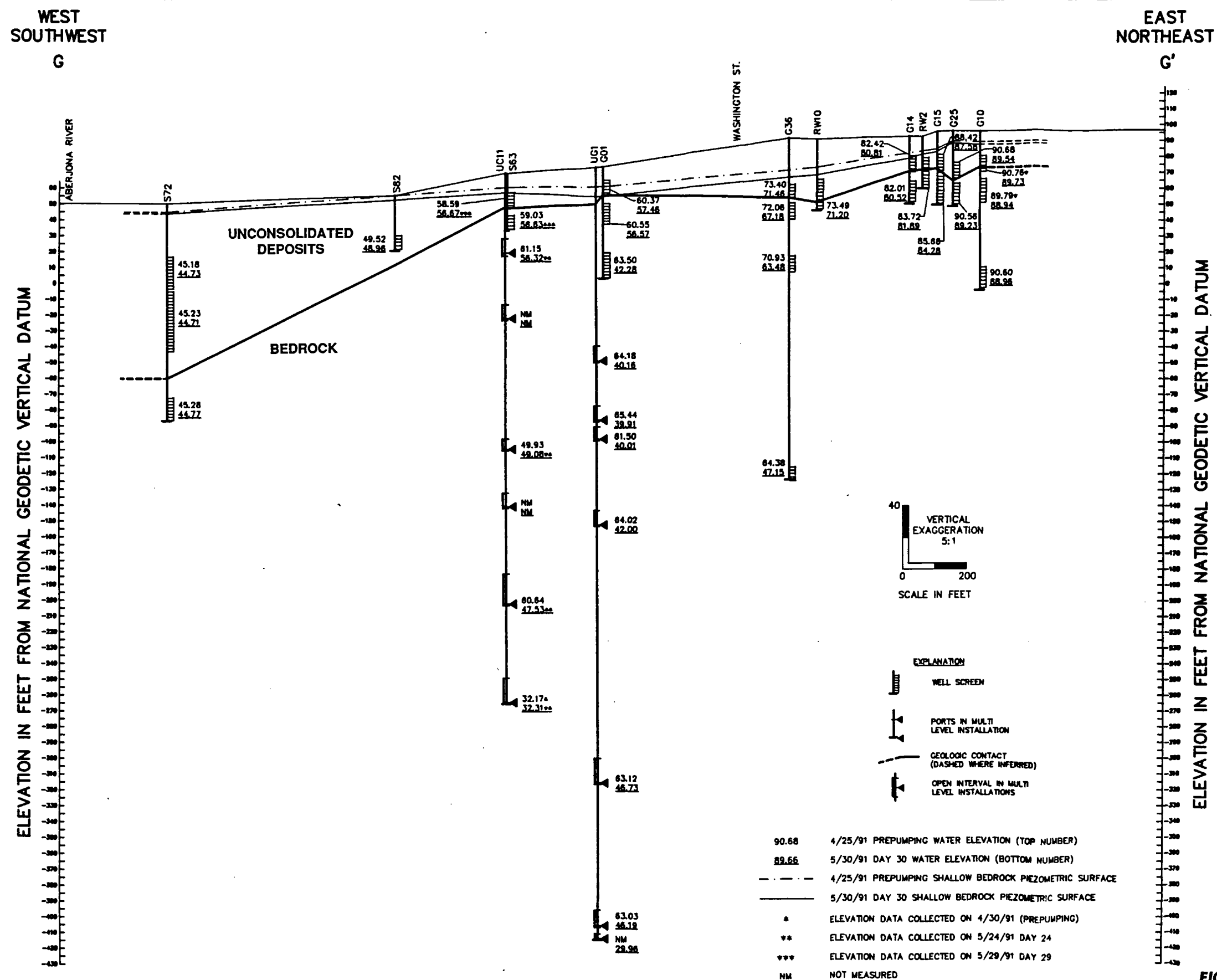
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FIGURE 3.1-9
Cross-Section E-E'
Estimated Potentiometric Surface of Shallow
Bedrock Before and On Day 30 of Pumping

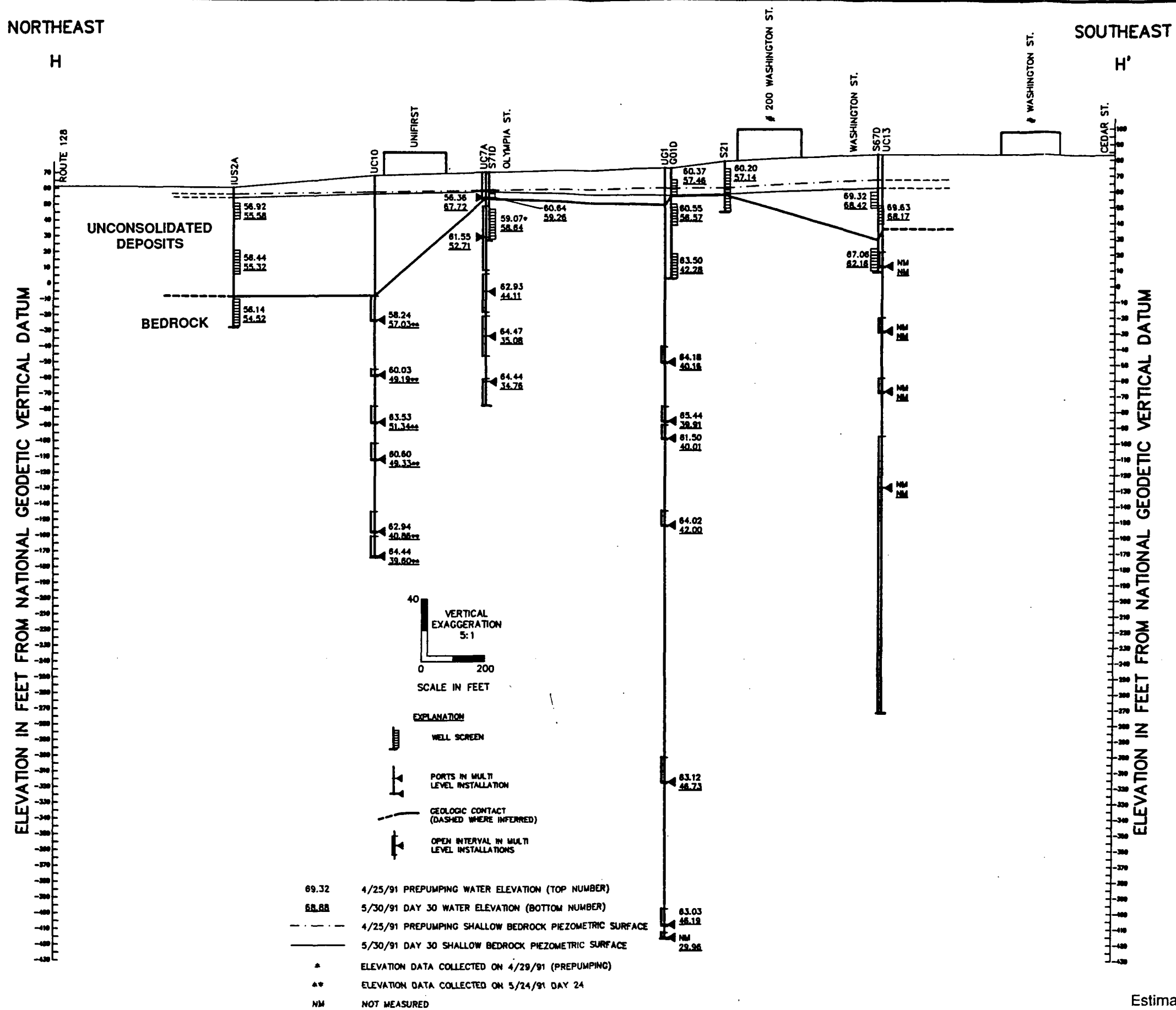


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FIGURE 3.1-10
Cross-Section F-F'
Estimated Potentiometric Surface of Shallow
Bedrock Before and On Day 30 of Pumping



NOTE: ONLY SHALLOW BEDROCK WELL DATA HAS BEEN USED IN THE PLOT OF THE PIEZOMETRIC SURFACE.



69.32	4/25/91 PREPUMPING WATER ELEVATION (TOP NUMBER)
<u>68.88</u>	5/30/91 DAY 30 WATER ELEVATION (BOTTOM NUMBER)
— — —	4/25/91 PREPUMPING SHALLOW BEDROCK PIEZOMETRIC SURFACE
—————	5/30/91 DAY 30 SHALLOW BEDROCK PIEZOMETRIC SURFACE
*	ELEVATION DATA COLLECTED ON 4/29/91 (PREPUMPING)
**	ELEVATION DATA COLLECTED ON 5/24/91 DAY 24
NM	NOT MEASURED



EXPLANATION

- G10 MONITORING WELL SCREENED IN DEEP BEDROCK
- OPEN BEDROCK PRODUCTION WELL CASSED THROUGH UNCONSOLIDATED DEPOSITS
- MONITORING WELL SCREENED IN BEDROCK AND UNCONSOLIDATED DEPOSITS
- 70 — LINE OF EQUAL WATER LEVEL ELEVATION MEASURED 5/30/91, FIVE FOOT CONTOUR INTERVAL
- △ 8-INCH WELL OPEN IN ROCK
- UC10-2* ASTERISK INDICATES MULTIPOINT WELLS, THE SECOND NUMBER (2) INDICATES THE PORT USED FOR THE WATER LEVEL MEASUREMENT
- APPROXIMATE GROUNDWATER CAPTURE AREA
- APPROXIMATE DOWNGRAIDENT BOUNDARY OF GROUNDWATER CAPTURE AREA

300 0 300

SCALE IN FEET

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Wells G & H Site
Woburn, MA

FIGURE 3.1-13

Groundwater Capture Area and Water Level
Contours of Bedrock Wells Showing the
Greatest Response to Pumping on Day 30

Prepared by ENSR and Consulting and Engineering

TABLE 3.1-2

Influent Volatile Organic Compounds - Laboratory Results (µg/L)

Sample Name	Sample Number	Sample Date	1,1-dichloro ethane	1,1-dichloro ethene	1,2-dichloro ethene	Tetrachloro ethene	Trichloro ethene	1,1,1-tri chloroethane
S1	1	4/11	<5.0	<5.0	<5.0	13.0	<5.0	<5.0
S1	2	4/11	<5.0	<5.0	<5.0	17.0	<5.0	<5.0
S1	3	4/30	<5.0	<5.0	<5.0	26.0	J4.0	<5.0
S1	4	5/01	<12.0	<12.0	<12.0	280.0	J11.0	<12.0
S1	5	5/02	<25.0	<25.0	<25.0	750.0	R	<25.0
S1	6	5/03	<50.0	<50.0	<50.0	1300.0	<50.0	<50.0
S1	7	5/04	<62.0	<62.0	<62.0	1600.0	<62.0	<62.0
S1	8	5/05	<62.0	<62.0	<62.0	1900.0	<62.0	<62.0
S1	9	5/06	<62.0	<62.0	<62.0	2200.0	R	<62.0
S1	10	5/07	<62.0	<62.0	<62.0	2200.0	<62.0	<62.0
S1	11	5/08	<100.0	<100.0	<100.0	2400.0	<100.0	<100.0
S1	12	5/09	<100.0	<100.0	<100.0	2700.0	<100.0	<100.0
S1	13	5/10	<100.0	<100.0	<100.0	3000.0	<100.0	<100.0
S1	14	5/11	<100.0	<100.0	<100.0	3100.0	<100.0	<100.0
S1	15	5/12	<100.0	<100.0	<100.0	2600.0	<100.0	<100.0
S1	16	5/13	<100.0	<100.0	<100.0	3500.0	<100.0	<100.0
S1	17	5/14	<100.0	<100.0	<100.0	3100.0	<100.0	<100.0
S1	18	5/15	<100.0	<100.0	<100.0	3200.0	<100.0	<100.0
S1	19	5/16	<100.0	<100.0	<100.0	3900.0	<100.0	<100.0
S1	20	5/17	<100.0	<100.0	<100.0	3300.0	<100.0	<100.0
S1	21	5/18	<100.0	<100.0	<100.0	3300.0	J78.0	<100.0
S1	22	5/19	<100.0	<100.0	<100.0	3300.0	<100.0	<100.0
S1	23	5/20	<100.0	<100.0	<100.0	3500.0	J85.0	<100.0
S1	24	5/21	<100.0	<100.0	<100.0	3400.0	J80.0	<100.0
S1	25	5/22	<100.0	<100.0	<100.0	3700.0	J87.0	<100.0
S1	26	5/23	<100.0	<100.0	<100.0	3900.0	J97.0	<100.0
S1	27	5/24	<100.0	<100.0	<100.0	3600.0	J92.0	<100.0
S1	28	5/25	<100.0	<100.0	<100.0	3800.0	J110.0	<100.0
S1	29	5/26	<100.0	<100.0	<100.0	3900.0	J99.0	R
S1	30	5/27	<100.0	<100.0	<100.0	4000.0	J110.0	J130.0
S1	31	5/28	<100.0	<100.0	<100.0	4100.0	110.0	<100.0
S1	32	5/29	<100.0	<100.0	<100.0	4400.0	110.0	<100.0
S1	33	5/30	<100.0	<100.0	<100.0	4000.0	120.0	<100.0

NOTES: "J" indicates that concentrations below detection limits were observed.

"R" indicates that the data was rejected by the data validator.

TABLE 3.1-3

**Influent Volatile Organic Compounds
A+RT Field Organics Analyzer System Results (µg/L)**

Sample Name	elapDate in May	Vinyl Chloride	1,1-dichloro ethene	T-DCE	1,1-dichloro ethane	C-DCE	1,2-dichloro ethane	Trichloro ethane	Trichloro ethene	Tetrachloro ethene
S1	16.0	0.00	11.3	0.0	4.2	14.0	0.00	33.3	65.0	3886
S1	17.2	0.00	7.4	0.0	3.6	15.3	0.00	31.4	61.5	3444
S1	17.7	0.00	7.4	0.0	4.4	16.9	0.00	36.4	75.5	4065
S1	18.3	0.00	9.8	0.0	3.7	17.2	0.00	30.3	69.8	3830
S1	18.9	0.00	9.8	1.1	4.3	17.6	0.00	37.1	73.6	3809
S1	19.1	0.00	9.7	0.0	3.5	17.5	0.00	35.2	70.8	3730
S1	19.9	0.00	12.1	.7	3.4	21.3	0.00	37.7	81.5	3875
S1	20.2	0.00	7.8	0.0	4.0	19.2	0.00	37.8	78.4	4027
S1	20.9	0.00	11.3	0.0	3.5	18.8	0.00	33.3	71.7	3582
S1	21.1	0.00	7.7	0.0	3.6	19.0	0.00	33.8	72.0	3706
S1	22.0	0.00	10.6	0.0	3.8	19.1	0.00	36.2	78.3	4058
S1	22.2	0.00	9.9	0.0	4.0	18.7	0.00	33.7	76.6	3843
S1	22.9	0.00	8.2	0.0	3.3	17.7	0.00	32.4	73.3	3730
S1	23.1	0.00	7.4	0.0	3.5	19.4	0.00	39.1	81.8	3766
S1	24.4	0.00	4.2	0.0	3.8	23.3	0.00	46.7	102.0	4856
S1	25.4	0.00	5.6	0.0	4.4	23.2	0.00	46.1	102.3	5083
S1	25.9	0.00	5.2	0.0	5.1	22.2	0.00	37.9	94.1	4983
S1	26.9	1.30	8.5	0.0	4.7	26.4	0.00	35.9	95.2	4304
S1	27.3	0.00	6.8	0.0	4.7	22.7	0.00	36.3	89.2	4189
S1	27.7	0.00	7.3	0.0	4.6	22.9	0.00	31.6	84.9	3975
S1	28.0	0.00	11.4	0.0	3.3	36.3	1.20	36.4	129.1	5294
S1	28.5	0.00	9.2	.6	4.2	21.0	0.00	26.1	71.7	
S1	28.6	0.00	10.6	1.3	2.7	19.5	0.00	29.2	83.8	3645
S1	28.9	0.00	12.2	0.0	2.7	18.0	0.00	29.4	79.7	3390
S1	29.2	0.00	9.1	0.0	2.3	16.9	0.00	27.8	78.2	3502
S1	29.5	0.00	7.6	0.0	2.7	19.6	0.00	31.1	91.4	4012
S1	29.7	0.00	5.7	0.0	2.8	16.9	0.00	28.5	81.2	3660
S1	30.0	0.00	6.1	0.0	2.0	16.4	0.00	25.6	77.5	3543
S1	30.3	0.00	5.2	0.0	2.0	17.4	0.00	27.6	80.5	3641

range of trichloroethene and 1,1,1-trichloroethane detected at lower concentrations. Tetrachloroethene constituted approximately 96 percent of the total mass detected from influent samples.

The mass removal rate is described above as a range during the 30-day pilot test due to the changing concentrations of tetrachloroethene with time and is presented on Figure 3.1-14. This figure shows a concentration increase of tetrachloroethene from approximately 10 to 2,000 micrograms per liter in six days followed by an increase from approximately 2,000 to 4,400 micrograms per liter in twenty-three days.

3.2 Hydraulic Response to Pumping, Grace Recovery Wells

During the period May 10 to May 20, ten extraction wells were pumped at an average total rate of about six gallons per minute. Six extraction wells (RW1-6) were located adjacent to the Grace building and parallel to the location of the former south drainage ditch (Figure 2.2-7). Four extraction wells (RW7-10) were located at the westerly portion of the Grace property and approximately parallel to Washington Street (Figure 2.2-7).

One purpose of the pilot test pumping from the Grace property was to evaluate the feasibility of creating a localized zone of hydraulic capture in the unconsolidated deposits and shallow bedrock on the Grace property (Figure 3.2-1). The localized zone of capture would create a hydraulic barrier to off-site migration of contaminated ground water in the unconsolidated deposits and shallow bedrock and, to the extent possible, remove contaminant mass from ground water beneath the Grace property.

At each of the two extraction locations on the Grace property, the extraction well system consists of a line of closely spaced wells which are screened in both the unconsolidated deposits and the upper ten feet of bedrock. One exception to that general description is well cluster G33 (RW4 and RW5). Well RW4 is cased through the unconsolidated deposits and is a 50-foot open-hole bedrock well. Well RW5 is only screened in the unconsolidated deposits and does not penetrate into bedrock.

The planned pumping procedure at each of the two extraction areas was to pump at the rate necessary to lower ground-water levels in the extraction wells to about two and one-half feet below the bedrock surface. Water levels in the extraction wells would be maintained at that level by high-level and low-level switches. Details of the extraction well configurations are contained in Section 4.3.1.3 of this report.

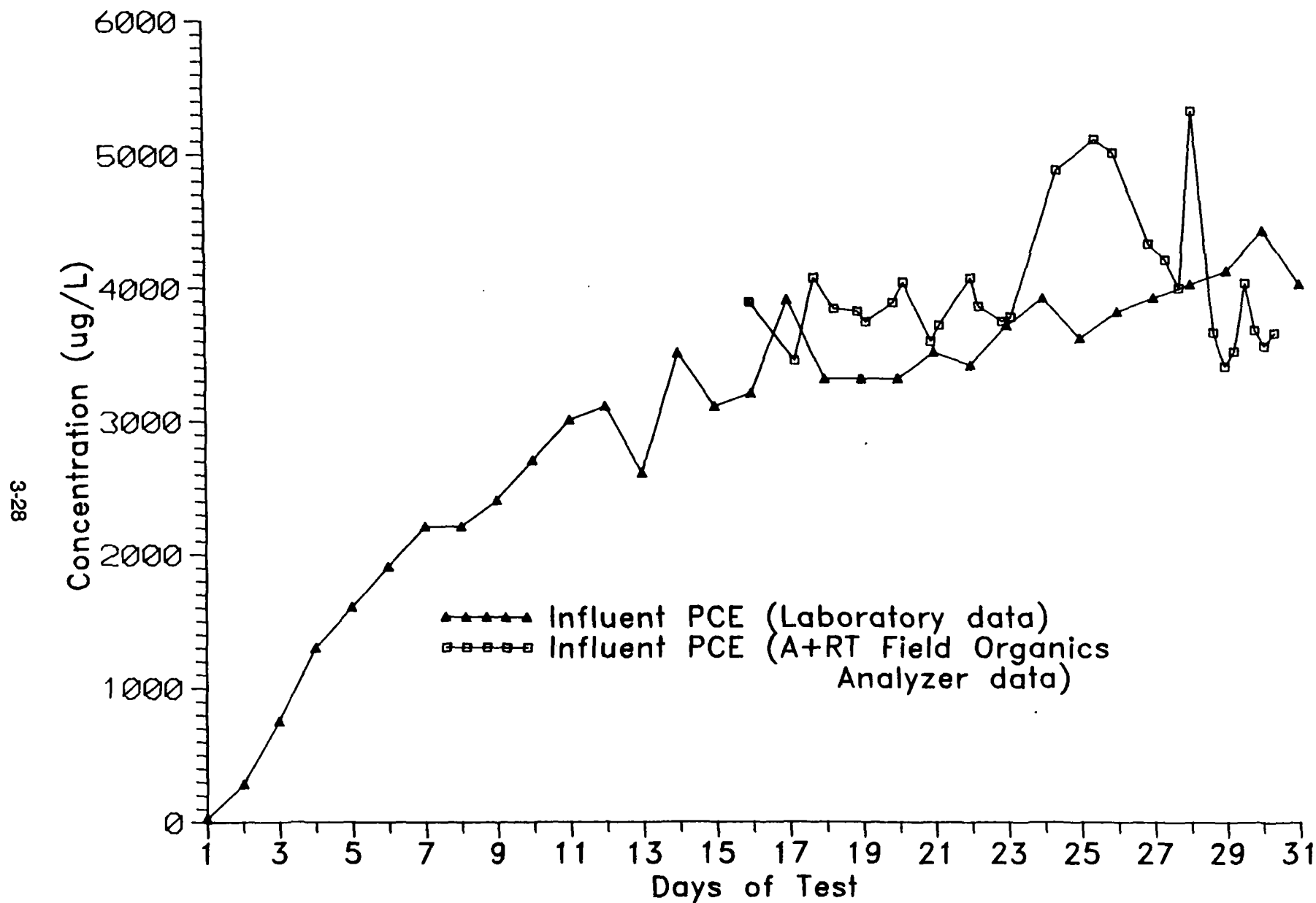
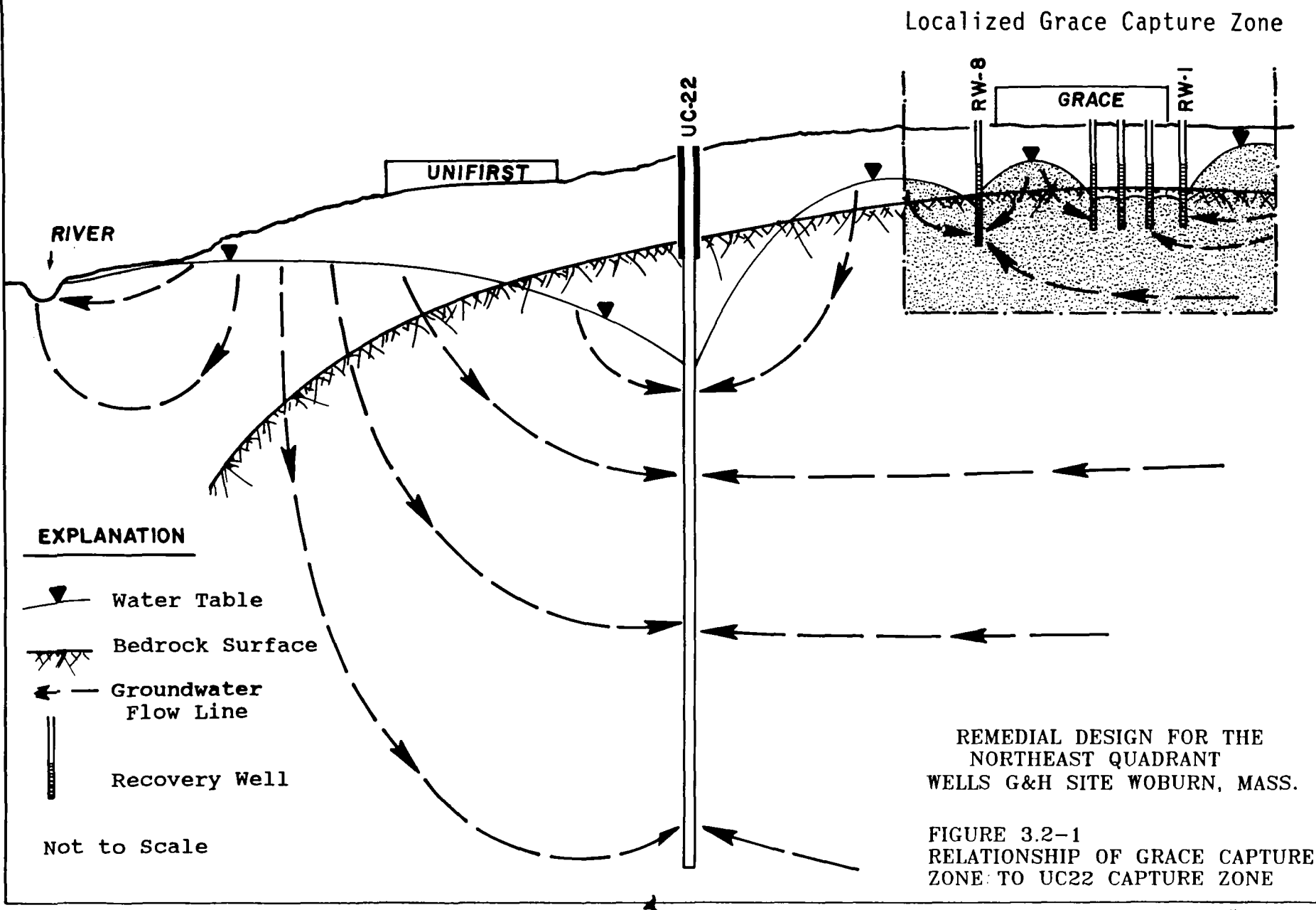


FIGURE 3.1-14

Influent Tetrachloroethene Concentration Versus Time



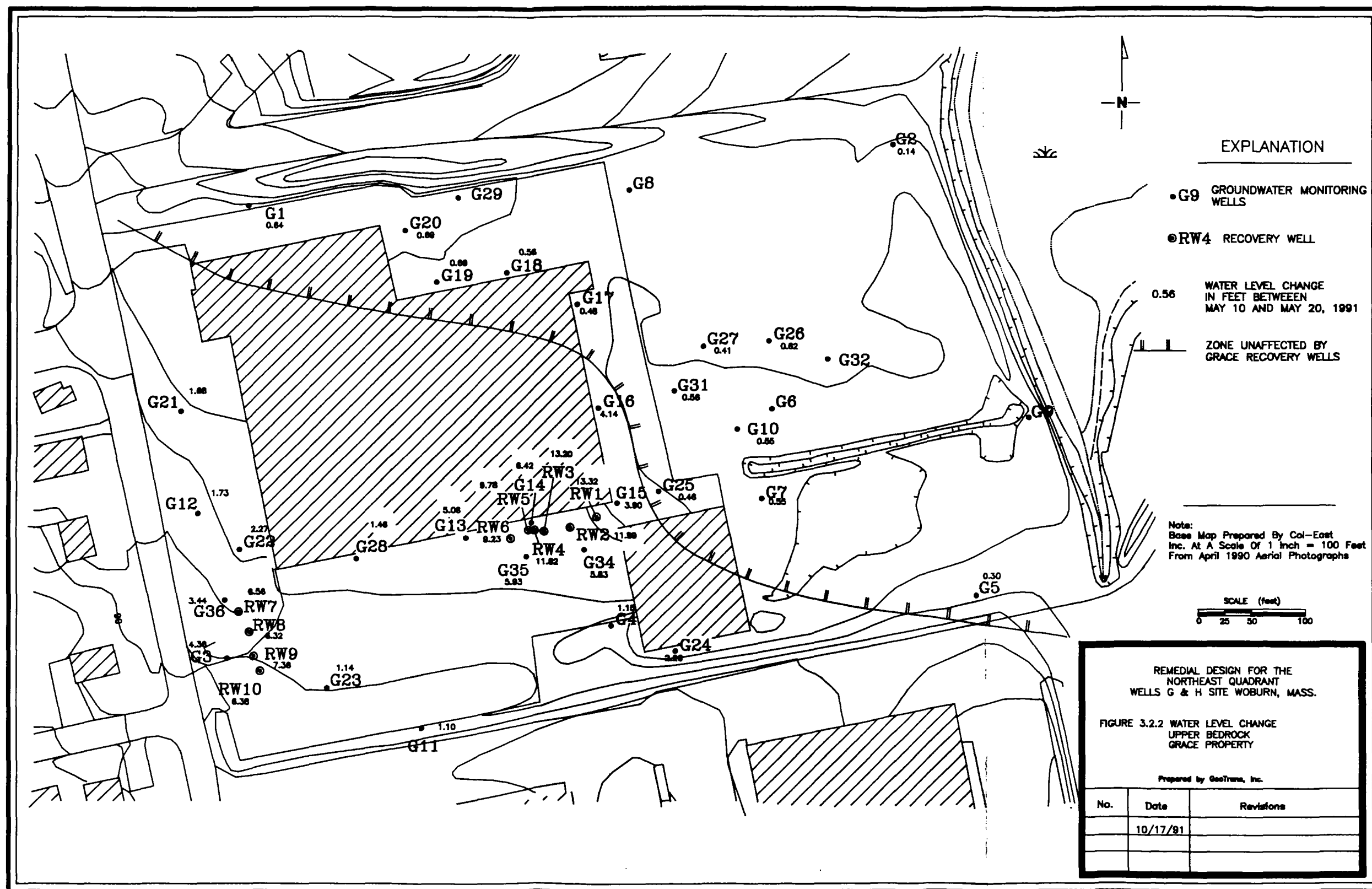
At the extraction area adjacent to the Grace building, the planned pumping procedure was generally achieved. Water levels in four of the six extraction wells were lowered below the bedrock surface. In well RW5, which did not penetrate into bedrock, the water level was lowered to about one foot above the bedrock surface. In well RW6, the water level was lowered to within two feet of the bedrock surface. The total extraction rate for this group of wells was about two gallons per minute during the early pumping period but had declined to less than 1.5 gallons per minute at the end of the ten-day pumping period. A long-term continuous pumping rate from this group of extraction wells would likely be about one gallon per minute.

At the extraction area located near Washington Street, the planned pumping procedure was not achieved. Water levels in the extraction wells were lowered eight to ten feet but were still about ten feet above the bedrock surface. Pump size constraints limited the pumping rate from each well to about one gallon per minute. The total extraction rate for this group of wells was about four gallons per minute. It is estimated that a long term extraction rate of about six gallons per minute could be sustained from this area and would lower water levels to below the elevation of the bedrock surface.

3.2.1 Hydraulic Response in the Bedrock

Pumping from the Grace site extraction wells affected water levels in both the bedrock and the unconsolidated deposits. In most cases, the hydraulic response in the bedrock was more noticeable than in the unconsolidated deposits. Figure 3.2-2 is a map of the water level change which occurred in upper bedrock wells between May 10 and May 20, 1991. This water level change represents the effects of a combination of factors, such as Grace on-site pumping, pumping from well UC22, and natural climatic conditions. Based on review of water level hydrographs for Grace on-site monitoring wells, it was estimated that a water level change of about 0.6 feet or less could have resulted from factors other than pumping from the Grace extraction wells. Water level declines greater than 0.6 feet probably reflect the effects of pumping from the Grace wells. Figure 3.2-2 illustrates the areas of the Grace property within which upper bedrock water levels were affected and unaffected by pumping from the Grace recovery wells. The area affected by the Grace pumping was generally the southwestern half of the property.

To determine the zone of influence resulting from the Grace pumping, individual hydrographs were analyzed to evaluate the amount of water level change attributable to the Grace pumping. Figure 3.2-3 is a water level hydrograph for well cluster G15. The "S" well is screened in the unconsolidated deposits and the "D" well is screened in the upper bedrock. The figure shows that, following May 10, the day the Grace wells began pumping, there was a noticeable decline in both the bedrock and unconsolidated deposit water levels. The figure also illustrates that, following May 20, the day the Grace wells were shut off, there was a noticeable rise in water



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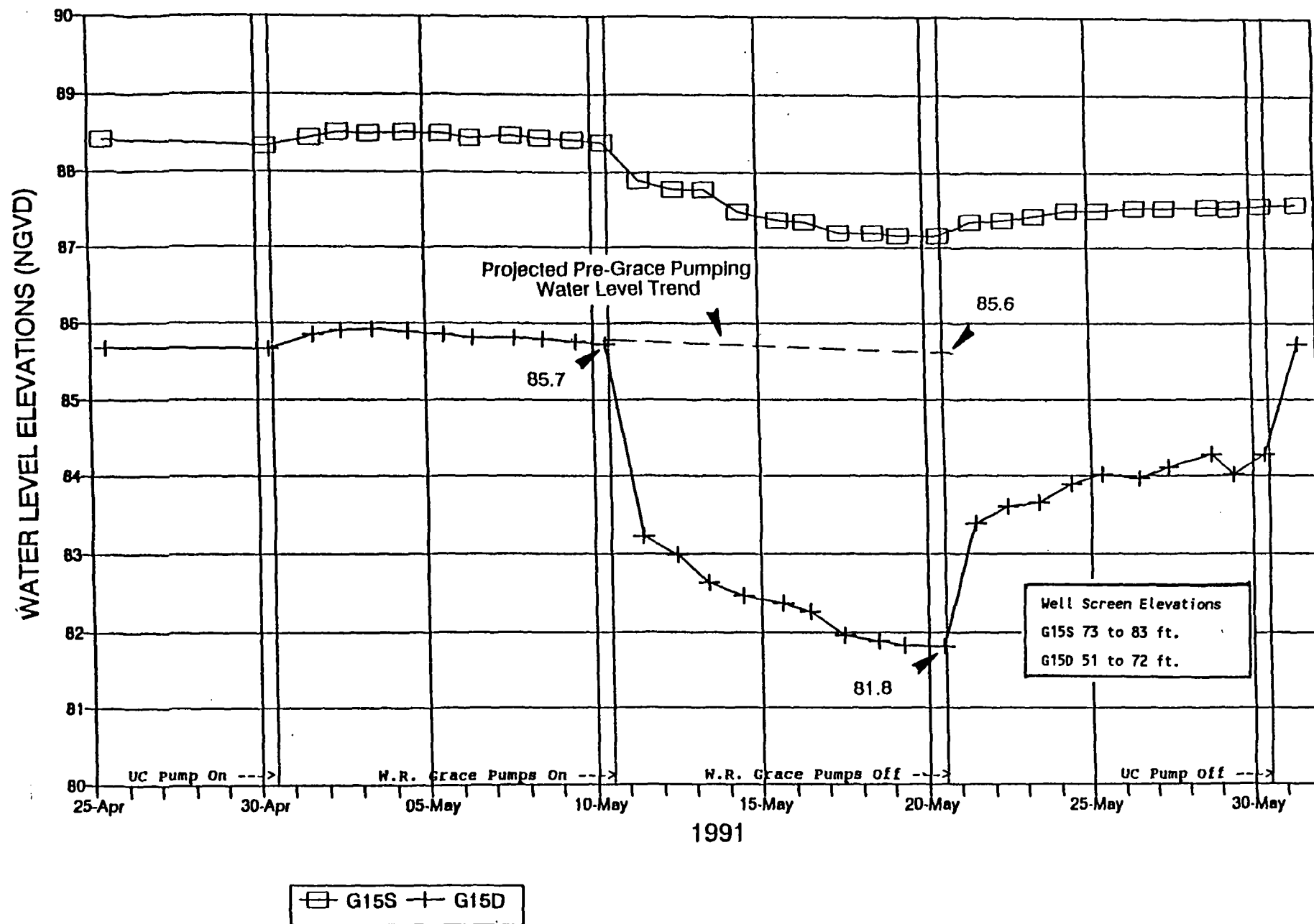


FIGURE 3.2-3

Water Level Hydrograph, Well Cluster G15

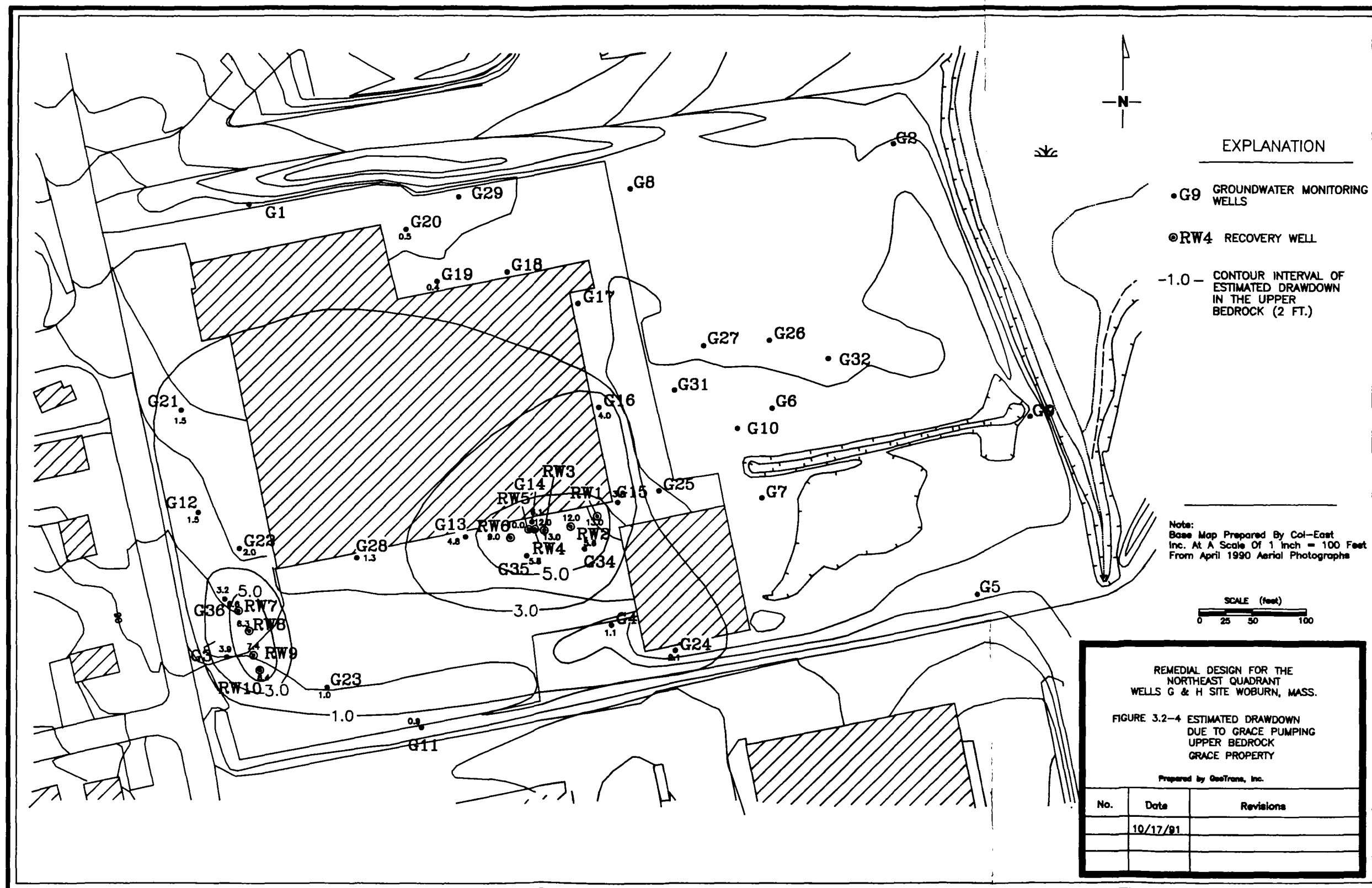
levels. The net water level change for well G15D between May 10 and May 20 was estimated to be about 3.9 feet (85.7-81.8) and the amount of water level change resulting from the Grace pumping was estimated to be about 3.8 feet (85.6-81.8). These estimates are probably accurate to within 0.2 feet. The estimated water level change at all on-site monitoring wells due to the Grace pumping was used to prepare Figure 3.2-4. The figure illustrates the estimated drawdown and shape of the zone of influence in the upper bedrock which resulted from pumping the Grace recovery wells for ten days. The outermost contour shown on the figure represents the region within which the drawdown exceeded one foot. The zone of influence of the Grace pumping extended beyond the one-foot contour line but could not be mapped.

3.2.2 Hydraulic Response in the Unconsolidated Deposits

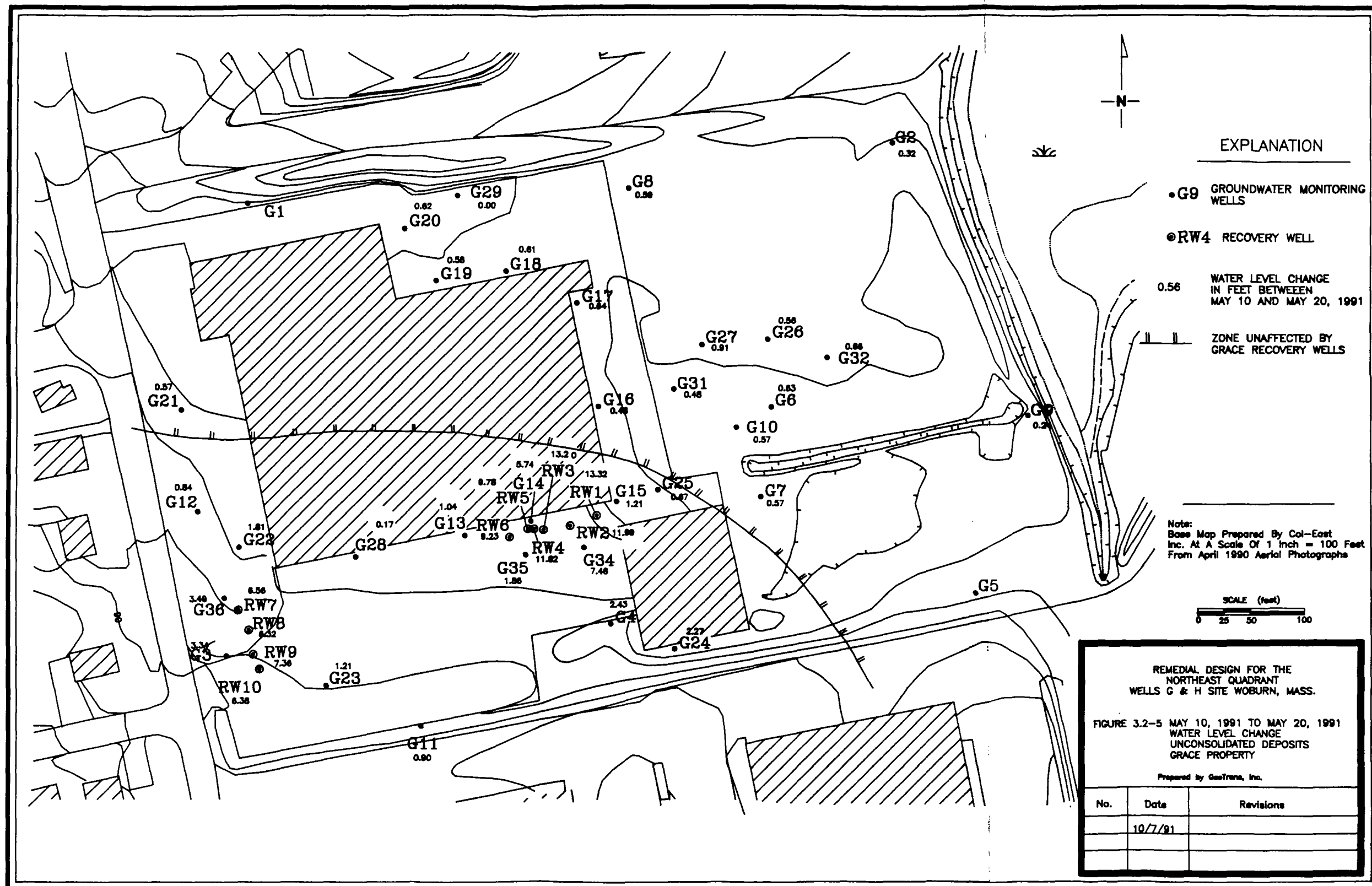
The hydraulic response in the unconsolidated deposits to the Grace pumping was similar to, but less extensive than, the hydraulic response in the bedrock. Figure 3.2-5 illustrates the net water level change which occurred in the unconsolidated deposits between May 10 and May 20, 1991. Assuming that as much as 0.6 feet of water level decline may be due to factors other than Grace pumping, the boundary between the area affected by and unaffected by Grace pumping is located closer to the southwestern corner of the Grace property than it was for the upper bedrock wells.

One likely reason for the differing response between the unconsolidated deposits and the bedrock is the difference in the storage properties of the two media. Within the bedrock, water is generally released from compressive storage which occurs relatively quickly. Within the unconsolidated deposits, however, water is also released from storage by gravity drainage. The slower release from storage by gravity drainage in the unconsolidated deposits results in a slower and more irregular rate of expansion of the zone of drawdown due to pumping. The phenomenon of less extensive drawdown in the unconsolidated deposits is illustrated in Figure 3.2-3. The rate of water level decline in the "S" well is slower and less extensive than in the "D" well. Figure 3.2-6 also illustrates the differential response to pumping of the unconsolidated deposits and the bedrock. Well cluster G21 is located on the westerly edge of the Grace property and is about 180 feet from the nearest Grace extraction well. There are noticeable water level declines and rises in well G21D in response to the Grace pumping. It is not clear, however, that water levels in well G21S have responded at all to the Grace pumping.

Figure 3.2-7 illustrates the drawdown and shape of the zone of influence in the unconsolidated deposits as a result of pumping the Grace extraction wells for ten days. The procedure used to prepare this map was similar to the procedure used to prepare the upper bedrock drawdown map. The area contained within the one-foot drawdown contour is less than for the upper bedrock. For a longer pumping period, however, when the effects of gravity drainage of the



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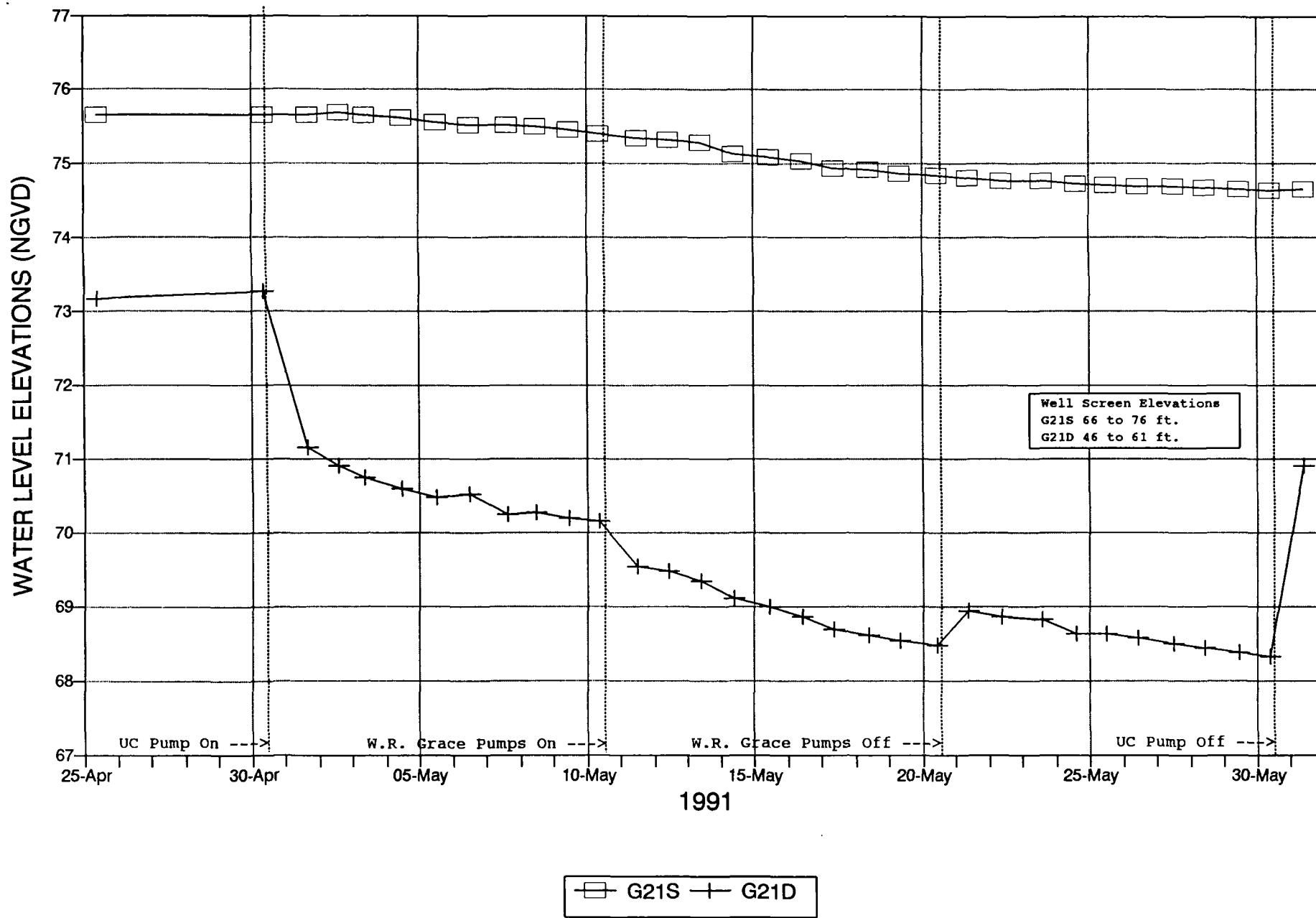
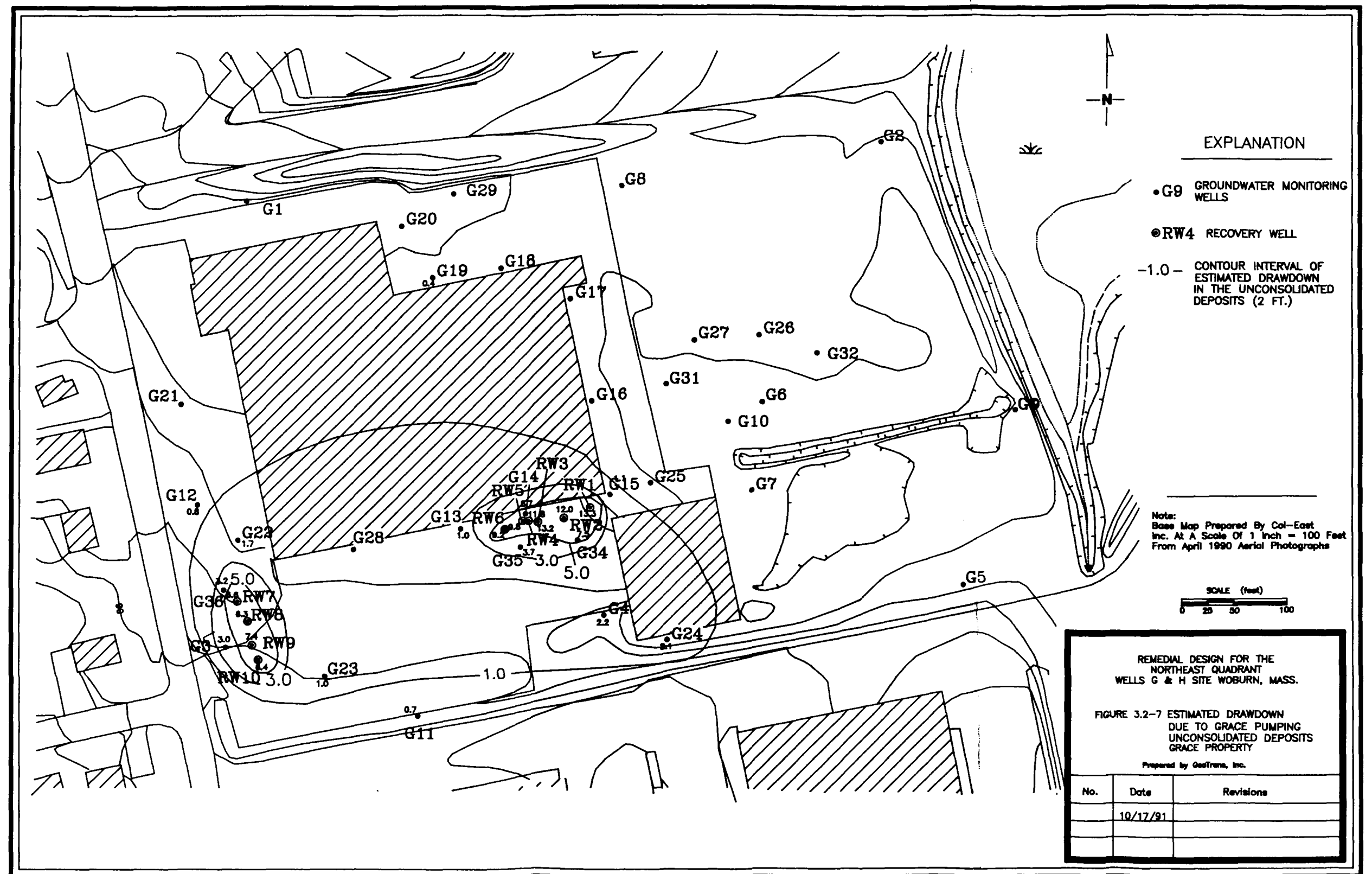


FIGURE 3.2-6



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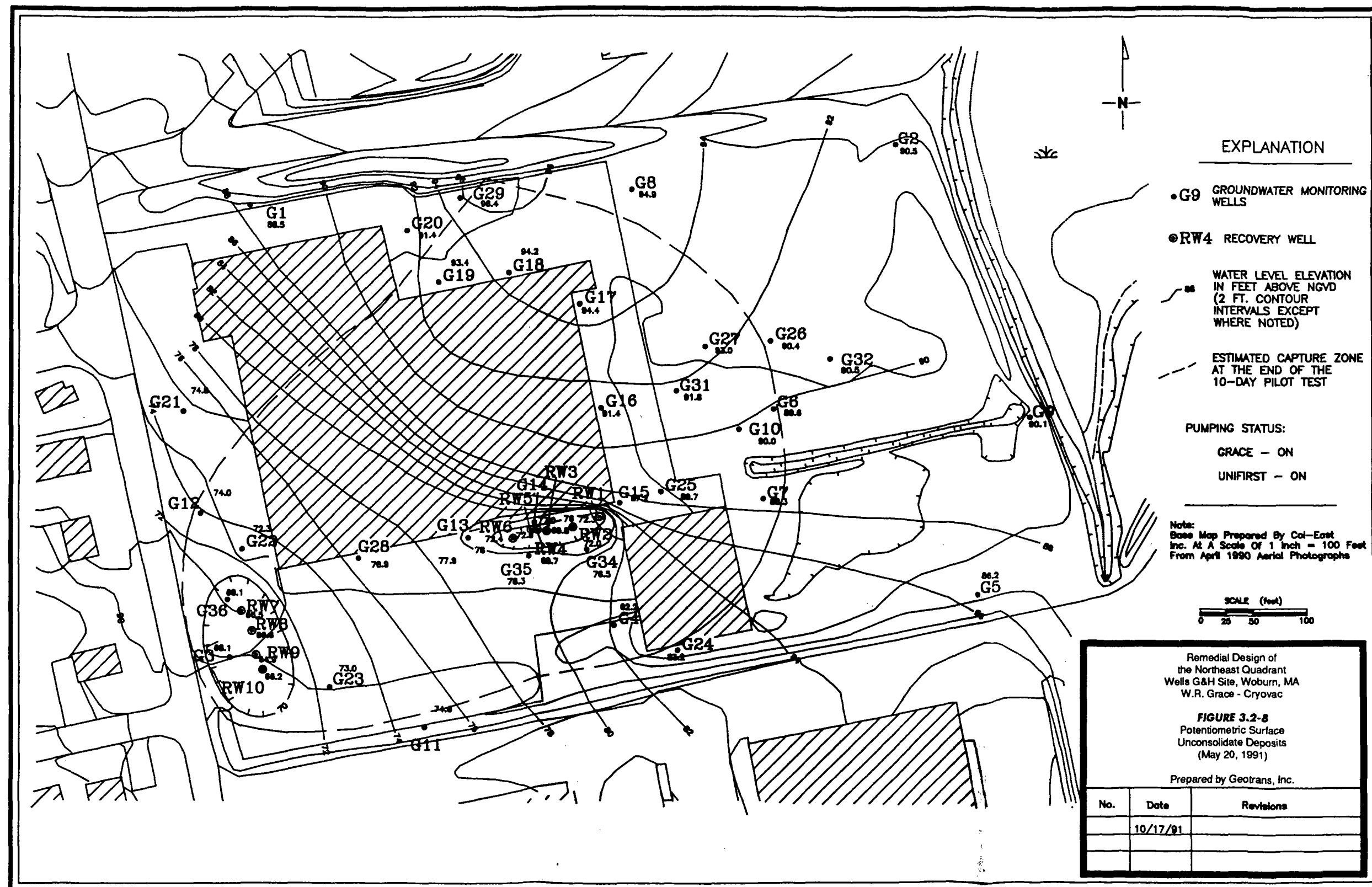
unconsolidated deposits are complete, the areal extent of the zone of influence within the unconsolidated deposits would likely be similar to the zone of influence within the shallow bedrock.

3.2.3 Zone of Capture of the Grace Pumping System

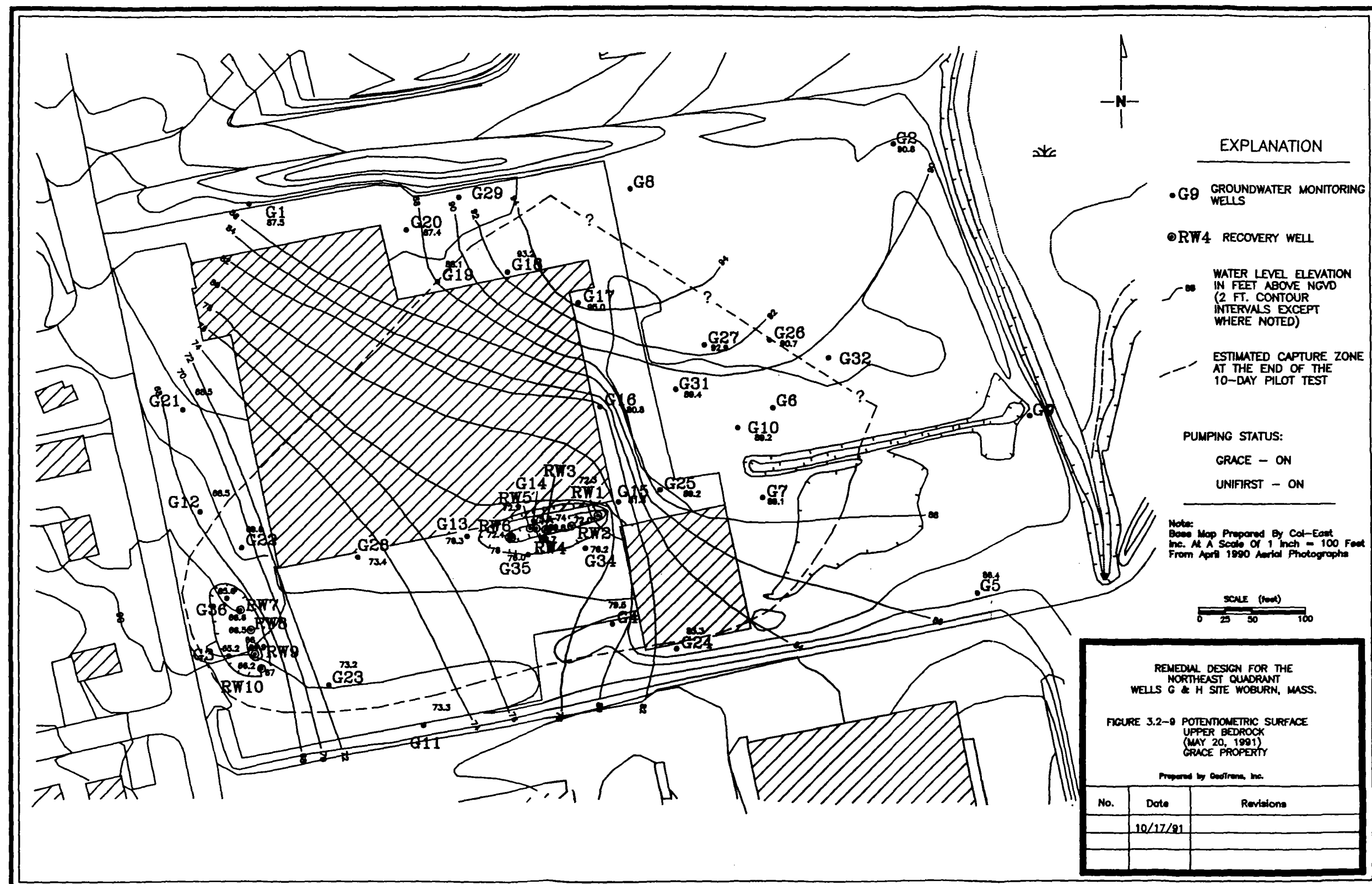
The zone of capture of the Grace pumping system was determined by preparing areal and sectional potentiometric maps. The water level data were collected on May 20, 1991, prior to shutting off the Grace extraction wells. The mapped boundary to the zone of capture is an approximate boundary which identifies the region within which ground water flowing beneath the Grace property would be diverted to the Grace on-property extraction wells. Water level data collected during the pilot test indicate that the zone of drawdown due to the Grace pumping was still expanding at the end of the planned pumping period. Consequently, the zone of capture of the Grace extraction wells was similarly expanding at the end of the pumping period.

Figures 3.2-8 and 3.2-9 are the May 20, 1991, potentiometric surfaces for the unconsolidated deposits and upper bedrock respectively. The boundary of the zone of capture within each of these hydrostratigraphic units is outlined on each of the figures. The lateral boundary of the capture zones was estimated from general principles of flow net analysis and assumes a homogeneous, isotropic medium with uniform and constant transmissivity. While these idealized assumptions are not representative of the Grace property, the deviations between site conditions and idealized assumptions are not likely to have a significant effect on the representations shown on Figures 3.2-8 and 3.2-9. The zone of capture encompasses the on-site contaminant source locations and extends to the southerly and westerly property boundaries.

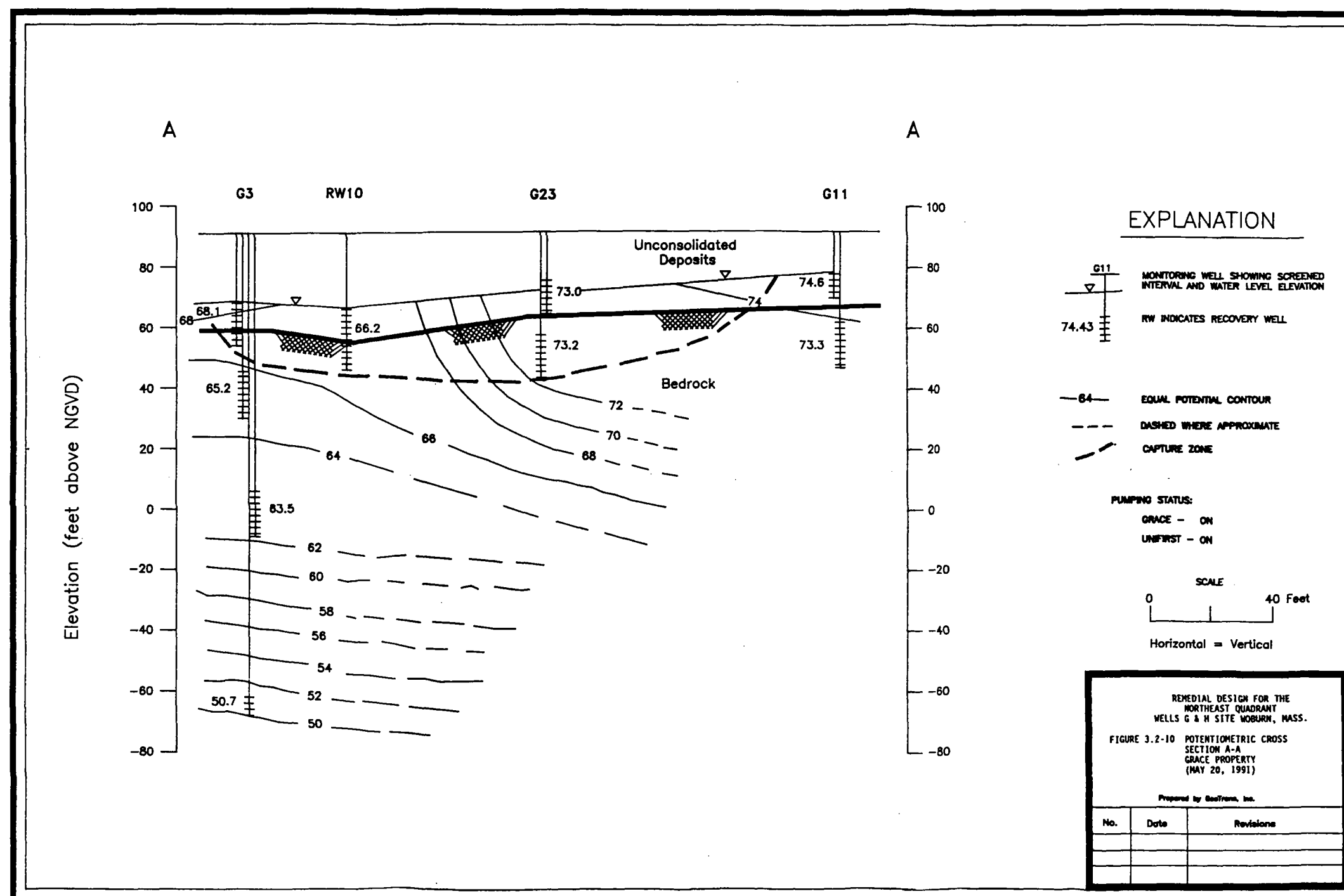
Figures 3.2-10, 3.2-11, and 3.2-12 are potentiometric sections which show the estimated vertical extent of the zone of capture beneath the extraction well areas on the Grace property. Figure 2.2-7 shows the location of these section lines. These potentiometric sections indicate that the vertical extent of the zone of capture of the Grace extraction wells extends into the shallow bedrock. The capture zone boundaries shown on these sections were also based on the general principles of flow net analysis. The sections are drawn with no vertical exaggeration and the capture zone boundary reflects a horizontal to vertical anisotropy of less than ten to one. The sections illustrate that contaminated ground water flowing in the upper bedrock beneath the Grace property would be diverted upward into the extraction wells. The figures also indicate that contaminated ground water in the deeper bedrock would not be captured by the Grace on-site system. The deeper bedrock contamination would be captured by pumping from well UC22.



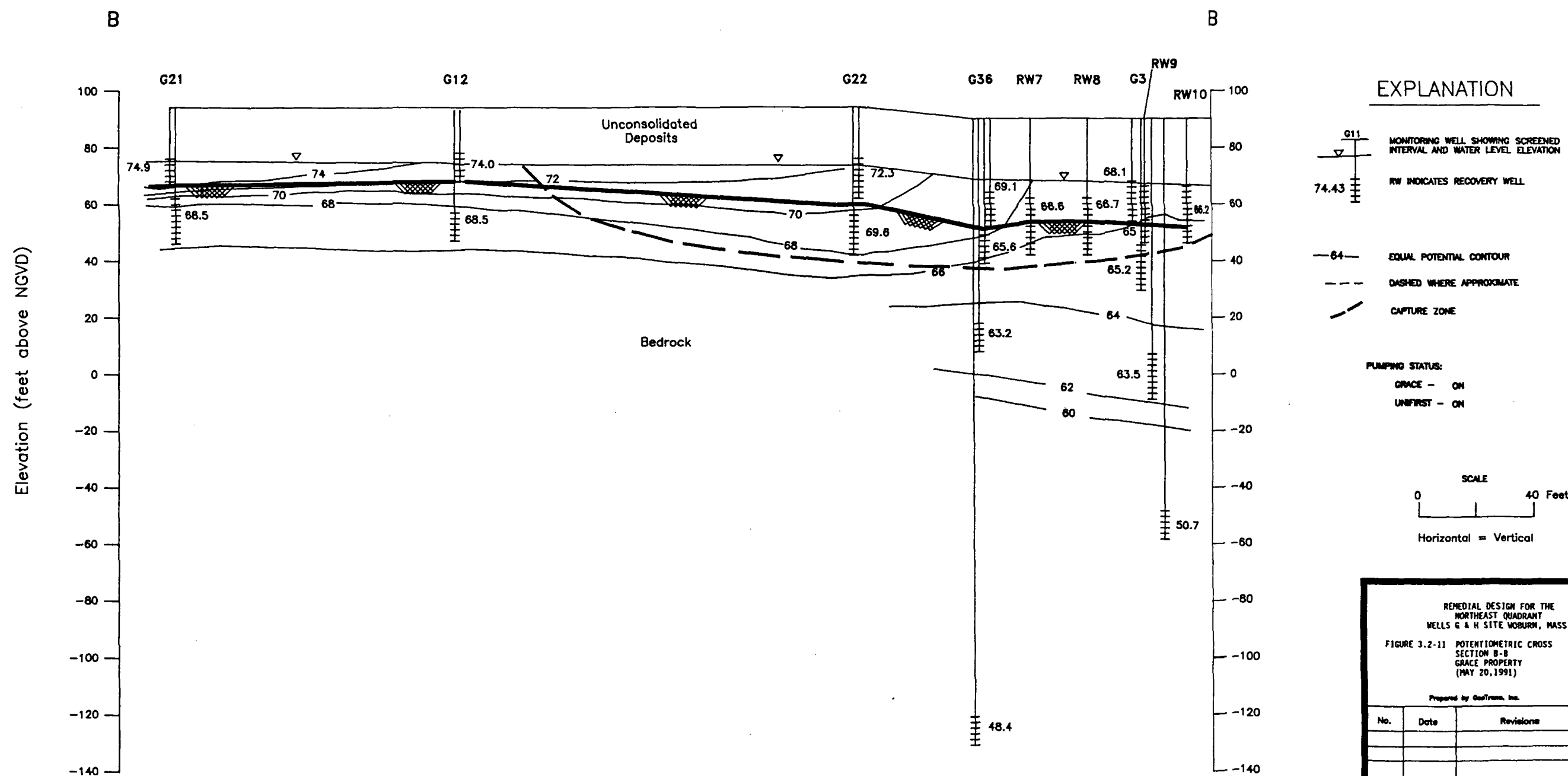
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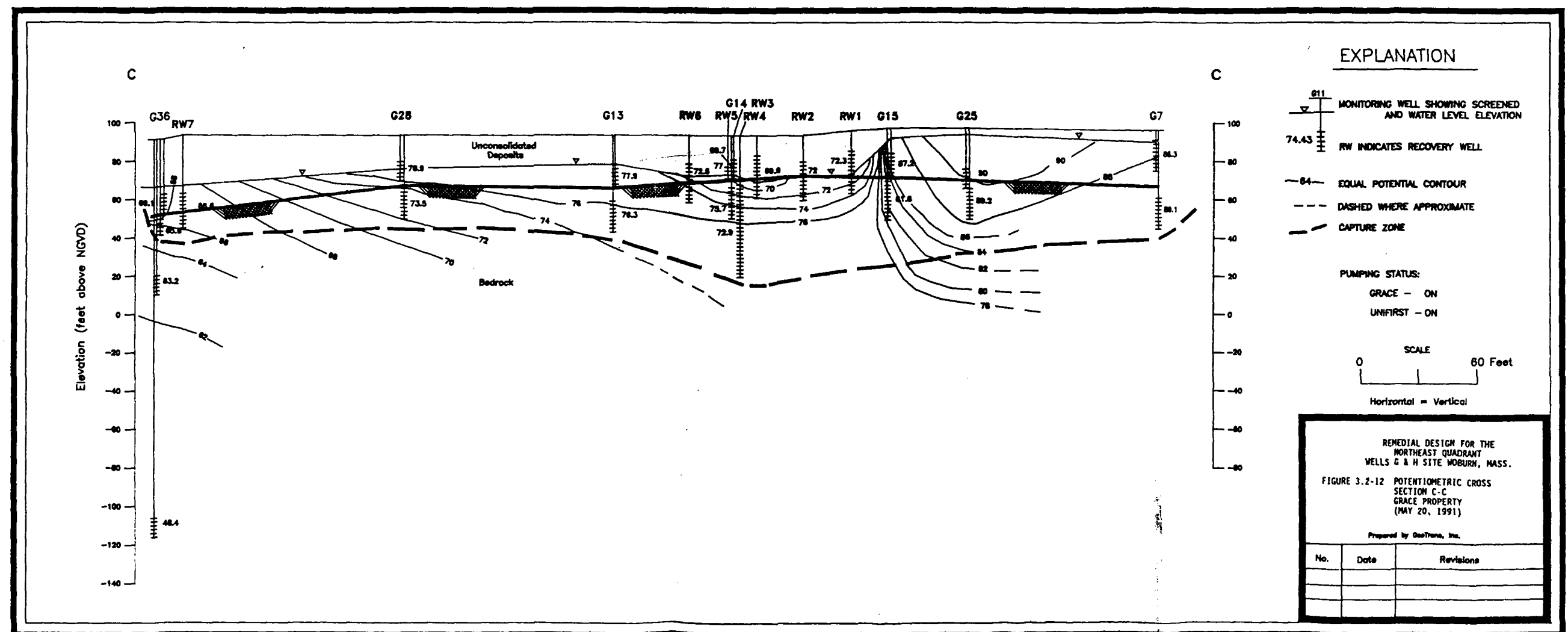
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3.2.4 Contaminant Mass Removal

During the ten-day period of pumping from the Grace extraction wells, the rate of contaminant mass removal ranged from about 0.20 to 0.07 pounds per day and averaged about 0.11 pounds per day. Tables 3.2-1 and 3.2-2 tabulate the daily mass removal rates for the two separate extraction well locations on the Grace property. The mass removal rates were calculated using the daily average pumping rates contained in Table 3.2-3 and the daily influent concentrations reported for each group of wells (Section 4.3.3.2, Tables 4.3-9 and 4.3-10). The mass removal rates are based on the compounds trichloroethene, 1,2 dichloroethene, and vinyl chloride. These compounds have been found relatively consistently in the ground water beneath the Grace property although the spatial distribution and relative concentrations have varied. Isolated occurrences of compounds which have not been found in the Grace ground water on a consistent basis were not included in the calculations.

Table 3.2-1 represents the extraction system located at the Washington Street property boundary. This line of wells is intended to create a hydraulic barrier to off-site chemical migration in the unconsolidated deposits and upper bedrock. The pumping rate from this group of four wells ranged from 5.5 to 3.6 gallons per day and represented about 70 percent of the total daily flow rate. The mass removal rate from this group of wells was about 0.04 pounds per day which is approximately 35 percent of the total average mass removal rate and slightly greater than the off-site chemical mass flux under non-pumping conditions (see Section 2.3.2.4). The primary constituents were trichloroethene and 1,2 dichloroethene. No vinyl chloride was reported for the discharge from this group of wells.

Table 3.2-2 represents the group of wells located adjacent to the former south drainage ditch. The flow rate from this group of wells ranged from 2.9 to 1.3 gallons per minute and represented about 30 percent of the total daily flow rate. The average mass removal rate from this group of wells was about 0.07 pounds per day, about 65 percent of the total average mass removal rate. During the first few days of the Grace pumping, mass removal rates from this location were about 0.1 pounds per day. At the end of the Grace pumping period, however, the removal rates had declined to less than 0.05 pounds per day. The more than fifty percent reduction in rate of mass removal from this location resulted from a combination of declining extraction rates and chemical concentrations. Both the total extraction rate and the influent concentrations declined by about 30 percent during the ten-day Grace pumping period. Primary constituents of the well discharge were trichloroethene, 1,2 dichloroethene, and vinyl chloride.

Figure 3.2-13 illustrates the daily mass removal rates from the combined Grace on-site extraction system and the daily mass removal rates from each of the two sections of the extraction system.

TABLE 3.2-1

Daily Contaminant Mass Removal Rates by Wells RW7-10
(units are pounds/day)

	5/10	5/11	5/12	5/13	5/14	5/15	5/16	5/17	5/18	5/19	5/20	Average
Trichloroethylene	.029	.025	.018	.013	.021	.022	.021	.016	.021	.016	.016	.020
1,2 dichloro- ethylene	.032	.023	.031	.015	.021	.021	.023	.020	.021	.017	.016	.021
Vinyl chloride	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	.061	.048	.049	.028	.042	.043	.044	.036	.043	.033	.032	.041 ²

TABLE 3.2-2

Daily Contaminant Mass Removal Rates by Wells RW1-6
(units are pounds/day)

	5/10	5/11	5/12	5/13	5/14	5/15	5/16	5/17	5/18	5/19	5/20	Average
Trichloroethylene	.001	.005	.001	.002	.002	-	.003	.005	.004	.004	.004	.003
1,2 dichloro-ethylene	.073	.045	.032	.045	.041	.040	.039	.033	.020	.022	.021	.037
Vinyl chloride	.066	.048	.044	.039	.033	.033	.027	.023	.018	.017	.015	.033
TOTAL	.140	.098	.077	.086	.076	.073	.069	.061	.042	.043	.040	.073 ²

Notes:

¹ For metric conversion, 1 pound (mass) = 453.6 grams.

² Total average is the sum of the averages.

- Not detected.

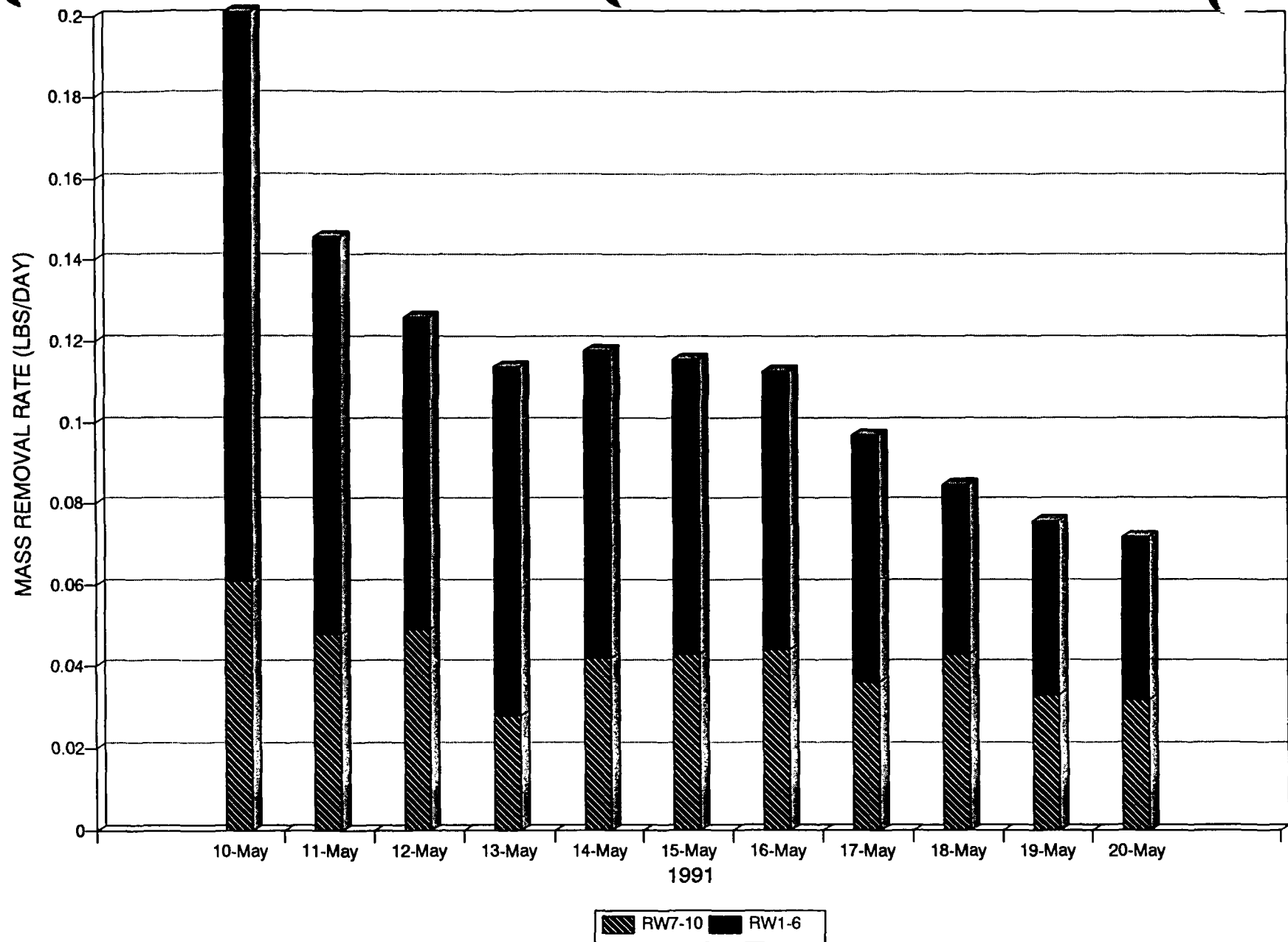
TABLE 3.2-3

Average Daily Pumping Rates for the Grace Extraction System
(units are gallons per minute)

	EXTRACTION RATES		
	RW1-6 ¹	RW7-10 ¹	TOTAL ²
May 10	2.88	5.54	8.17
May 11	1.98	4.65	6.56
May 12	1.92	3.75	5.42
May 13	2.18	3.73	5.65
May 14	2.12	3.86	5.98
May 15	1.97	3.76	5.50
May 16	2.03	4.35	5.91
May 17	1.72	4.46	6.12
May 18	1.54	4.02	5.25
May 19	1.42	3.79	5.05
May 20	1.31	3.63	5.48

Notes:

1. The extraction rate is the sum of individual flow meter readings for each well.
2. The extraction rate was measured in a separate flow meter which measured the combined discharge of all wells.

**FIGURE 3.2-13**

Daily Contaminant Mass Removal Rate
Grace Recovery System

3.3 Recommended Ground-Water Extraction Systems

3.3.1 UniFirst Ground-Water Extraction System

The ground-water extraction system on the UniFirst property will consist of continuous pumping of well UC22 at the rate of 50 gallons per minute. The results of the 30-day pilot test of the UniFirst ground-water extraction system indicate a capture area which exceeds one of the primary objectives in the ROD by preventing migration of contaminated ground water from the UniFirst and Grace properties to the Central Area of the Wells G & H Site. Based on extensive water-level data collected throughout the Northeast Quadrant, the ground-water capture area extends off the UniFirst property in all directions encompassing all of the Grace property with a maximum horizontal extent of approximately 1,500 feet south of the UniFirst property and a vertical extent greater than 480 feet.

The recommended ground-water extraction rate on the UniFirst property of 50 gallons per minute from well UC22 is expected to create a ground-water capture area which will expand beyond the capture area measured in the shallow bedrock during the 30-day pilot test with increased reaction in the unconsolidated deposits. This anticipated capture area will extensively exceed the capture area required in the ROD for the UniFirst and Grace properties in the Northeast Quadrant of the Wells G & H Site and provide mass removal of contamination that has already flowed from and well beyond the two property boundaries.

3.3.2 Grace Ground-Water Extraction Systems

The results of the ten-day pilot testing on the Grace property indicate that it is feasible to create a localized hydraulic capture zone on the Grace property to stop off-site migration of contamination and to remove contaminant mass from the ground water beneath the property. The hydraulic capture zone which developed during the ten-day pilot test extended approximately to the southerly and westerly property boundaries and the lateral extent of contamination on the Grace property. The zone of capture also extended vertically into the upper bedrock beneath the Grace property. The zone of drawdown and, consequently, the zone of capture of the Grace extraction system was expanding at the end of the test. It seems likely, therefore, that the extraction system which has already been installed at the Grace property may be sufficient to achieve the remedial design work plan objective for remedial action at the Grace property.

Notwithstanding the likelihood that the existing system may be adequate for remedial action at the Grace property, some modifications and extensions to the existing system are proposed. These modifications and extensions are designed to address discrete localized areas of contamination and to provide more extensive hydraulic gradient control at the property

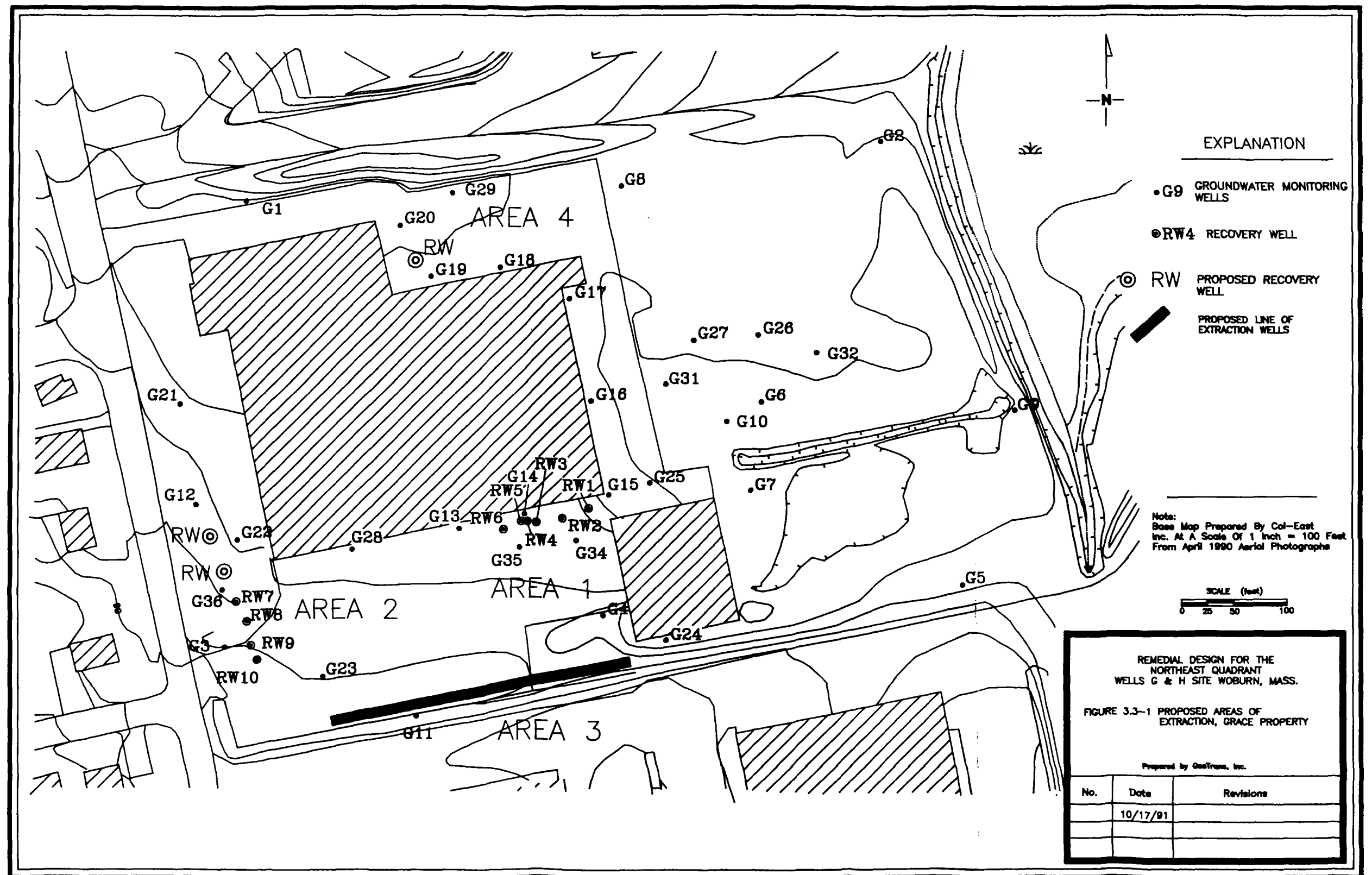
boundaries. Figure 3.3-1 illustrates the discrete areas of the Grace property where ground-water extraction will occur to create a property wide remedial action. Plans for ground-water extraction from these areas are summarized below:

Area 1 (RW1-RW6) - No change to system configuration is planned. Cyclic operation of the extraction system in this area is planned. The cyclic operation will allow ground-water levels to resaturate the unconsolidated deposits beneath the former south drainage ditch and likely provide for more efficient contaminant mass removal from this location. The timing of the pumping and non-pumping operational cycles will be determined from removal efficiency testing to be done during the initial operation of the extraction system. Anticipated testing cycles are two weeks pumping, one week non-pumping; four weeks pumping, one week non-pumping; and six weeks pumping, one week non-pumping. Extraction from this area would continue as long as the rate of mass recovery is reasonably effective compared to other on-site extraction locations. Extraction from this area will likely be discontinued within a few years as the rate of mass removal declines.

Area 2 (RW7-RW10) - Add two extraction wells to the northerly end of the line of extraction wells. Well construction would be similar to wells RW7-RW10. Higher yield pumps are to be installed in all wells. Pump at a higher total rate than occurred during the pilot test to lower water levels to below the bedrock surface. Additional wells and lowered water levels will create a wider and deeper zone of capture than occurred during the ten-day pilot test. The expected long-term pumping rate from this area is about six gallons per minute.

Area 3 - Install a line of recovery wells between existing wells G23 and G24. About nine wells spaced 25 feet apart will be installed along this line. Well construction will be similar to the recovery wells in Area 2. That is, wells will be screened in both the unconsolidated deposits and upper 10 feet of bedrock. The line of wells will provide a more extensive capture zone along the southern boundary of the Grace property. The total flow to this group of wells will likely be less than five gallons per minute.

Area 4 - Install large diameter caisson type well to a depth of 20 feet. The well will be operated as a sump collection system in the low permeability material to extract contaminated ground water from a localized area of relatively high contaminant concentrations. Expected water flow rate is less than one gallon per minute.



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3.4 Effects of Other Pumping Wells on Ground-Water Levels

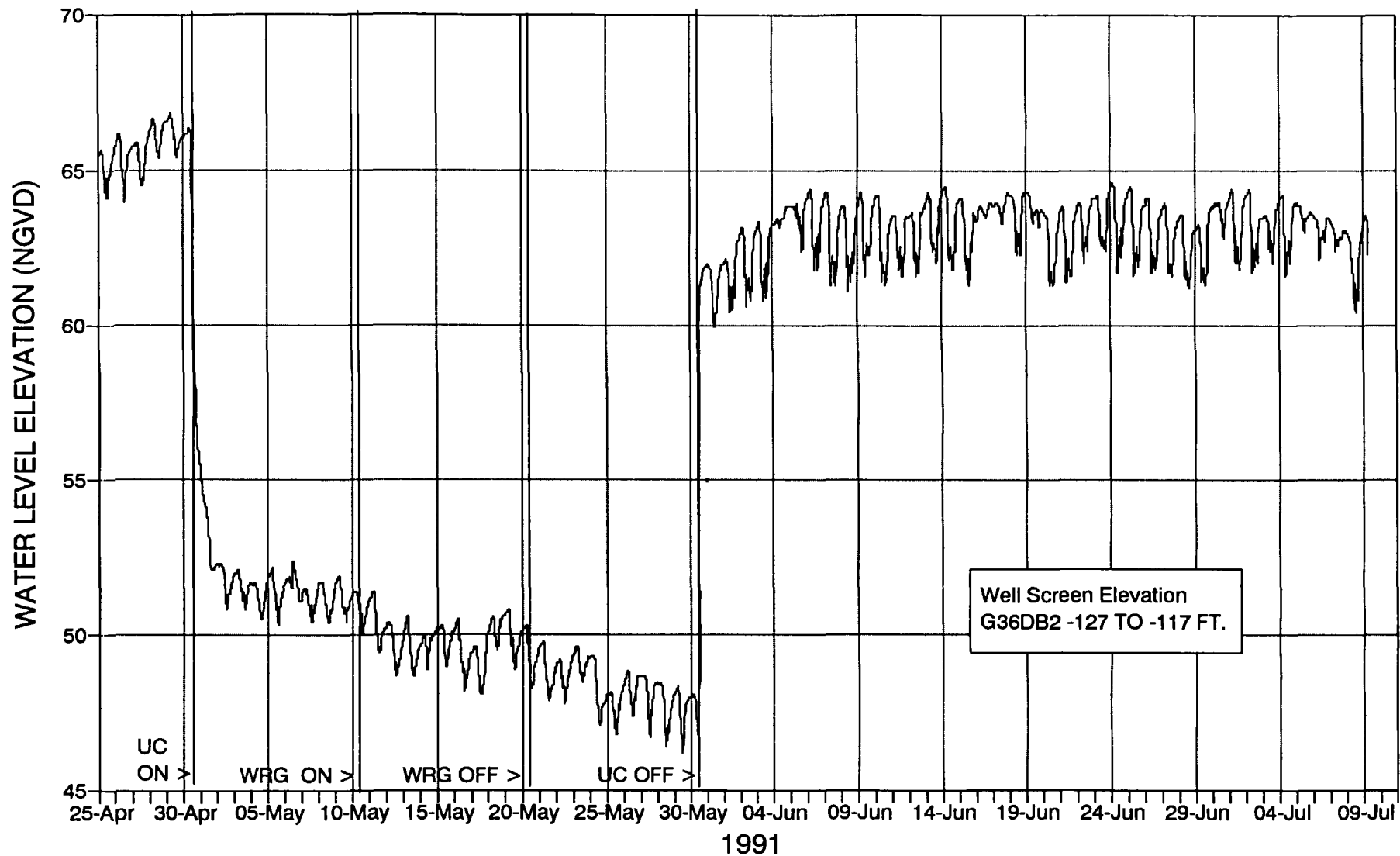
During the 30-day pilot test, it was noted that there were cyclic, or periodic, water level fluctuations which were unrelated to pumping from well UC22 or the Grace extraction system. Some of the fluctuations were of such regular periodicity and low amplitude that they likely represented the effects of earth tides (see data logger hydrographs for wells G13D and G25D, Appendix B). Other fluctuations, however, were of larger amplitude and less regular periodicity such that they likely represented the effects of other nearby pumping wells. Figure 3.4-1, which is a water level hydrograph for well G36DB2, illustrates these interference effects of other pumping wells. The large change in water level (about 20 feet) which occurred between April 30 and May 30 resulted from pumping well UC22. The daily water level fluctuations, which had an amplitude of about two feet, reflect interference effects from one or more nearby pumping wells.

Table 3.4-1 is based on review of the water level data collected as part of the pilot test. The table shows the wells for which the water level hydrographs (Appendix B) indicate a noticeable response to pumping from well UC22, the Grace extraction wells, or other cyclic factors. For purposes of this evaluation, a noticeable response to pumping from well UC22 or the Grace extraction wells is defined to be a directly correlative water level decline or rise in response to starting or stopping pumping from UC22 or the Grace extraction wells. Other conditions, such as a gradual water level decline which exceeded the average natural water level decline or incomplete water level recovery following cessation of Grace pumping, were not categorized as noticeable responses to pumping even though these conditions may have resulted from pumping from UC22 or the Grace extraction wells. For about 25 wells, particularly the deeper wells, there is a recognizable water level response to cyclic factors, which is not related to pumping from well UC22 or the Grace extraction system.

At present, the specific well, or wells, which may be causing the cyclic fluctuations are not known but a preliminary inquiry to the Massachusetts Department of Environmental Protection, Division of Water Supply, has noted the existence of five bedrock production wells which are located in reasonably close proximity to the Wells G & H Site such that they may be causing the periodic water level fluctuations (Dave Delaney, US EPA, personal communication, June 7, 1991).

The issue of the cause of the periodic water level fluctuation is not critical to the design of the remedial actions to be implemented at the UniFirst and Grace properties, but is significant for two reasons. First, it is clear that there are conditions external to the Wells G & H Site which affect water levels and consequently hydraulic gradients within the Wells G & H Site. For purposes of understanding and identifying the factors which affect ground-water flow in the bedrock, knowledge of the external wells which may be causing the cyclic or periodic

3-53



— G36DB2

FIGURE 3.4-1

Table 3.4-1

Summary of Noticeable Water Level Response to Pumping
and Other Cyclic Factors

Well #	Response to UC22 Pumping	Response to Grace Pumping	Response to Other Cyclic Factors
EPA1	-	-	-
EPA2	-	-	-
EPA3	-	-	-
G1S	-	-	-
G1D	-	-	-
G1DB	-	-	-
G1DB2	Y	-	-
G1DB3	-	-	-
G2S	-	-	-
G2M	-	-	-
G2D	-	-	-
G3S	-	Y	-
G3D	Y	Y	-
G3DB	Y	Y	Y
G3DB2	Y	-	-
G3DB3	-	-	-
G4S	-	Y	-
G4D	-	Y	-
G5S	-	-	-
G5D	-	-	-
G6S	-	-	-

Table 3.4-1 (Continued)

Well #	Response to UC22 Pumping	Response to Grace Pumping	Response to Other Cyclic Factors
G7S	-	-	-
G7D	-	-	-
G8S	-	-	-
G9S	-	-	-
G10S	-	-	-
G10D	-	-	-
G10DB	-	-	-
G11S	-	Y	-
G11D	-	Y	-
G12S	-	Y	-
G12D	Y	Y	Y
G13S	-	Y	-
G13D	-	Y	Y
G14S	-	Y	-
G14D	-	Y	Y
G15S	-	Y	-
G15D	Y	Y	Y
G16S	-	-	-
G16D	-	Y	-
G17S	-	-	-
G17D	-	-	-
G18S	-	-	-

Table 3.4-1 (Continued)

Well #	Response to UC22 Pumping	Response to Grace Pumping	Response to Other Cyclic Factors
G18D	-	-	-
G19S	-	-	-
G19M	-	-	-
G19D	-	-	-
G20S	-	-	-
G20M	-	-	-
G20D	-	-	-
G21S	-	-	Y
G21D	Y	Y	Y
G22S	-	Y	-
G22D	Y	Y	-
G23S	-	Y	-
G23D	-	Y	-
G24S	-	Y	-
G24D	-	Y	-
G25S	-	-	-
G25D	Y	-	Y
G26S	-	-	-
G26D	-	-	-
G27S	-	-	-
G27D	-	-	-
G28S	-	Y	-

Table 3.4-1 (Continued)

Well #	Response to UC22 Pumping	Response to Grace Pumping	Response to Other Cyclic Factors
G28D	Y	Y	Y
G29S	-	-	-
G31S	-	-	-
G31D	-	-	-
G32S	-	-	-
G34S	-	Y	-
G34D	Y	Y	Y
G35S	-	Y	-
G35D	Y	Y	Y
G35DB	Y	Y	Y
G36S	-	Y	-
G36D	Y	Y	Y
G36DB	Y	Y	Y
G36DB2	Y	-	Y
G01S	Y	-	-
G01D	Y	-	-
G01DB	Y	-	Y
IUS1	Y	-	-
IUS2A	-	-	-
IUS2B	-	-	-
IUS3A	Y	-	Y
IUS3B	-	-	Y

Table 3.4-1 (Continued)

Well #	Response to UC22 Pumping	Response to Grace Pumping	Response to Other Cyclic Factors
IUS3C	-	-	-
NEPA	Y	-	Y
NEPB	Y	-	Y
NEP1	-	-	-
NEP2	-	-	-
NEP3	-	-	-
NEP101	-	-	-
NEP101B	-	-	-
NEP102	-	-	-
NEP102B	-	-	-
NEP103	-	-	-
NEP103B	-	-	-
NEP104	-	-	-
NEP104B	-	-	-
NEP105B	-	-	-
NEP106B	-	-	-
NEP107B	-	-	-
NEP108A	-	-	-
NEP108B	-	-	-

Table 3.4-1 (Continued)

Well #	Response to UC22 Pumping	Response to Grace Pumping	Response to Other Cyclic Factors
NEP109	-	-	-
NEP110B	-	-	-
RW1	-	Y	-
RW2	-	Y	-
RW3	-	Y	-
RW4	-	Y	-
RW5	-	Y	-
RW6	-	Y	-
RW7	Y	Y	-
RW8	Y	Y	-
RW9	Y	Y	-
RW10	Y	Y	-
S5	-	-	-
S6	-	-	-
S7	-	-	-
S8	-	-	-
S21	Y	-	-
S22	-	-	-
S39	-	-	-
S40	-	-	-
S63S	Y	-	Y
S63D	Y	-	Y
S64S	-	-	-
S64M	-	-	-
S64D	-	-	-

Table 3.4-1 (Continued)

Well #	Response to UC22 Pumping	Response to Grace Pumping	Response to Other Cyclic Factors
S65S	-	-	-
S65M	-	-	-
S65DR	-	-	-
S66	Y	-	-
S67S	Y	-	Y
S67M	-	-	-
S67D	Y	-	Y
S68S	-	-	-
S68D	-	-	-
S69D	Y	-	-
S70S	-	-	-
S70M	-	-	-
S70D	Y	-	-
S71S	-	-	-
S71D	-	-	-
S72S	-	-	-
S72M	-	-	-
S72D	-	-	-
S73S	-	-	-
S73D	-	-	-
S74S	-	-	-
S74D	-	-	-

Table 3.4-1 (Continued)

Well #	Response to UC22 Pumping	Response to Grace Pumping	Response to Other Cyclic Factors
S81S	-	-	-
S81M	-	-	-
S81D	-	-	-
S82	-	-	-
S84S	-	-	-
S84M	-	-	-
S84D	-	-	-
S85S	-	-	-
S85M	-	-	-
S86S	-	-	-
S86D	-	-	-
S87S	-	-	-
S87M	-	-	-
S87D	-	-	-
S88S	-	-	-
S88M	-	-	-
S88D	-	-	-
S89S	-	-	-
S89M	-	-	-
S89D	-	-	-
S90S	-	-	-
S90M	-	-	-
S90D	-	-	-

Table 3.4-1 (Continued)

Well #	Response to UC22 Pumping	Response to Grace Pumping	Response to Other Cyclic Factors
S91S	-	-	-
S91M	-	-	-
S91D	-	-	-
S93S	-	-	-
S93M	-	-	-
S93D	-	-	-
S94S	-	-	-
S94M	-	-	-
S94D	-	-	-
S95S	-	-	-
S95M	-	-	-
S95D	-	-	-
S97S	-	-	-
S97M	-	-	-
S97D	-	-	-
UC4	Y	-	-
UC5	Y	-	Y
UC6	Y	-	-
UC7A-1	Y	-	-
UC7A-2	Y	-	-
UC7A-3	Y	-	-
UC7A-4	Y	-	-
UC7A-5	-	-	-

Table 3.4-1 (Continued)

Well #	Response to UC22 Pumping	Response to Grace Pumping	Response to Other Cyclic Factors
UC8	-	-	-
UC9-2	Y	-	-
UC9-4	Y	-	-
UC9-6	Y	-	-
UC10-1	Y	-	-
UC10-2	Y	-	-
UC10-3	Y	-	-
UC10-4	Y	-	-
UC10-5	Y	-	-
UC10-6	-	-	-
UC11-1	-	-	-
UC11-2	Y	-	-
UC11-4	-	-	-
UC11-6	Y	-	-
UC12-1	Y	-	-
UC12-4	Y	-	-
UC12-5	-	-	-
UC12-6	-	-	-
UC14-1	Y	-	-
UC14-2	Y	-	-
UC14-3	Y	-	-
UC14-4	-	-	-
UC14-5	-	-	-
UC15S	Y	-	-
UC15D	Y	-	-

Table 3.4-1 (Continued)

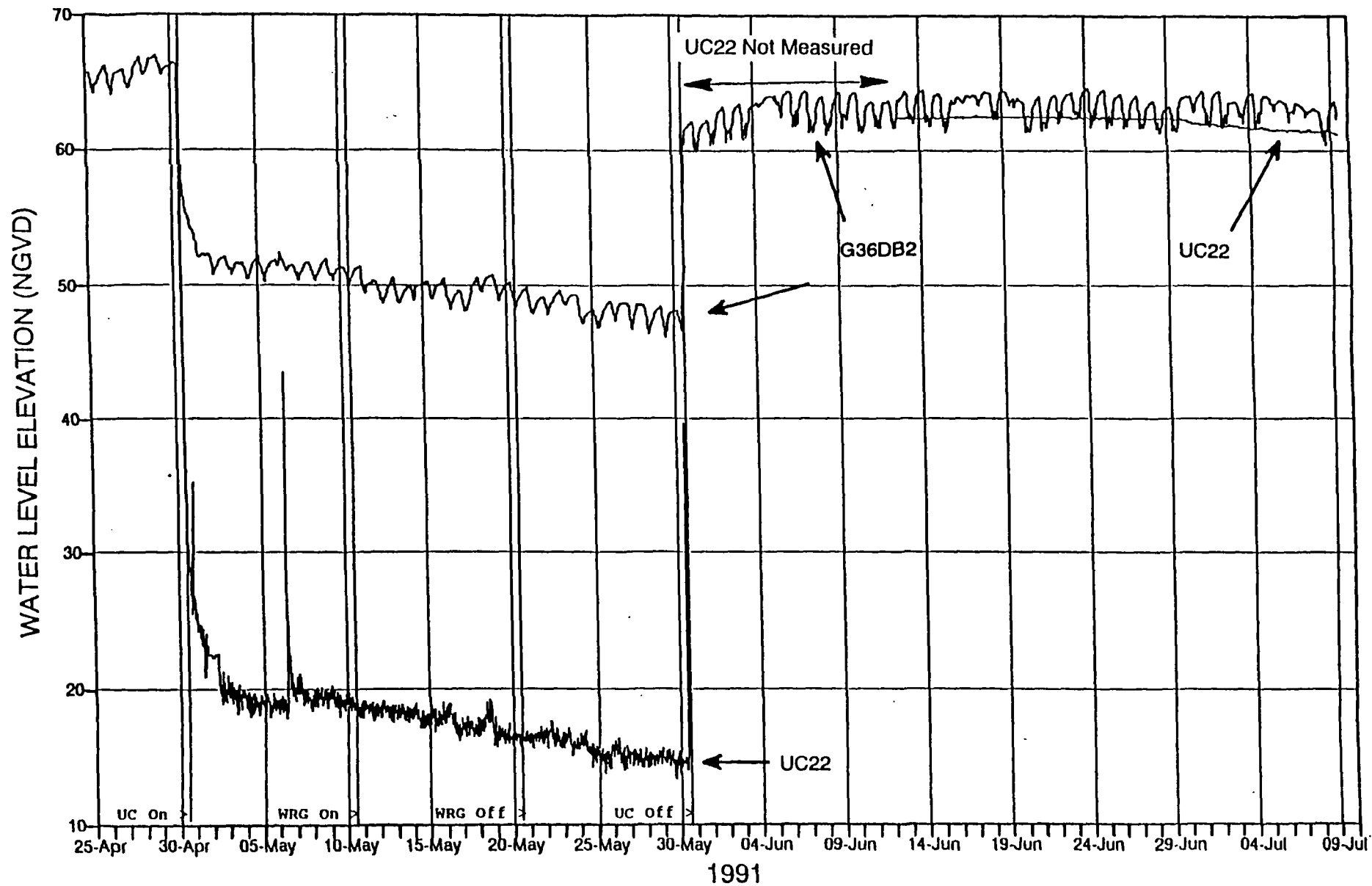
Well #	Response to UC22 Pumping	Response to Grace Pumping	Response to Other Cyclic Factors
UC16	Y	-	Y
UC17	-	-	-
UC18	Y	-	-
UC19	Y	-	-
UC20	Y	-	-
UC22	Y	-	-
UC23-1	-	-	-
UC23-2	Y	-	-
UC23-3	Y	-	-
UC23-4	Y	-	-
UC23-5	Y	-	-
UG1-1	-	-	-
UG1-2	Y	-	-
UG1-3	Y	-	-
UG1-4	Y	-	-
UG1-5	Y	-	-
UG1-6	Y	-	-
UG1-7	Y	-	-

fluctuations is necessary. This issue is primarily related to conceptualizing the hydrogeologic framework and is a necessary, but not critical, component of the Central Area RI/FS.

For purposes of evaluating whether the external pumping effects have affected, or would likely affect, the migration of contamination, the issue of identifying external production wells may be more important. Figure 3.4-2 is a composite hydrograph for wells G36DB2 and UC22. The hydrograph illustrates that, when UC22 was not pumping (June 12 to July 9), there was a periodic reversal of hydraulic gradient between the UniFirst and Grace properties. This reversal of hydraulic gradient does not necessarily mean that ground-water flow directions were reversed between the two properties but does indicate that there are daily variations in ground-water flow direction due to the periodic effects of the external production wells.

To provide a better basis for understanding and evaluating the hydraulic significance of the observed periodic water level fluctuations, two separate data collection activities have been planned. The first is additional bedrock water level monitoring and the second is installation of two additional bedrock monitoring wells on the eastern edge of the Grace property.

The proposed water level monitoring will include "continuous" water level monitoring in approximately 15 bedrock wells for a period of two to three months. The purpose of the monitoring is to help identify the cause of the periodic water level fluctuations observed during the 30-day pilot test and to identify wells which would be suitable for long-term monitoring during the Central Area RI/FS. The proposed well installation on the Grace property is to provide additional information regarding vertical and horizontal hydraulic gradients within the bedrock beneath the Grace property and to characterize water quality in the deeper bedrock at the eastern edge of the Grace property. The well installation on the Grace property is expected to be completed during 1991. The water level monitoring would occur in 1991 provided logistical details regarding controlling bedrock production well pumping schedules can be worked out.

**FIGURE 3.4-2**

Composite Hydrographs of Wells UC22 and G36 DB2

4.0 TREATABILITY TESTS

4.1 Introduction

The remediation strategy for the Northeast Quadrant involves bedrock pumping from Well UC22 at the UniFirst property and extraction of ground water from the unconsolidated deposits at the Grace property. The proposed management of the extracted ground water involves separate treatment systems and direct discharges for both the UC22 water and the extracted shallow ground water at Grace. In order to obtain design data for the final treatment systems, treatability tests were run at UniFirst during a 30 day period of pumping of UC22 in May, 1991, and within that 30-day period, a 10 day treatability test was run at the Grace property.

The overall goals of these treatability tests were as follows:

1. Ensure that discharge limits were not exceeded during the period of pumping,
2. Obtain treatability and design information for the proposed treatment processes, and
3. Better characterize the influent quality for the purposes of design.

Treatment systems were designed and constructed at each property and operated during the pumping period to facilitate the treatability tests. This section presents a description of the treatment systems, a summary of the operation of the systems, and the results of the treatability tests and overall treatment system performance for each of the two systems. The treatment system for the UC22 well water was located at the UniFirst property and the results from that test are presented in Section 4.2: UniFirst Treatability Test. The overburden and shallow bedrock ground-water extraction system and associated treatment system was located at the Grace property, and the results of that treatability test are presented in Section 4.3: Grace Treatability Test.

4.2 UniFirst Treatability Test

4.2.1 Background

4.2.1.1 Design Basis

The maximum design flow was selected at 50 gallons per minute (gpm). This decision was based on the hydraulic response from a previously performed 72-hour pump test (1989) which

was run at 20 gpm. This previous test provided some data as to the expected drawdown and yield of UC22 as well as the hydraulic response to the pumping in area monitoring wells. It was determined from the results of the 72-hour test that increasing the flow to 50 gpm for this extended pumping test would demonstrate a more favorable hydraulic response for remediation purposes, and so this was selected as the maximum design flow for the extraction and treatment systems for the treatability test.

Anticipated influent contaminants and associated concentrations were developed using all available data from previous tests. Analytical results from the previous 72-hour pumping test, area monitoring well sample analyses and the anticipated zone of influence of pumping UC22 were all evaluated to estimate influent concentrations. The primary contaminants of concern and their anticipated influent concentrations that were used as the basis for the design of the treatment system for the treatability test are summarized in Table 4.2-1.

The potential for vinyl chloride in the ground water existed, as this contaminant has been detected in monitoring wells on adjacent properties that potentially would be within the area of influence of pumping UC22. This compound and the potential for exposure to it influenced the design of the treatment system. Vinyl chloride adsorbs poorly to granular activated carbon (G.A.C.) and as a result, Ultra-Violet/Chemical Oxidation (U.V.), which treats vinyl chloride easily, was selected as the primary treatment process. This process also had the potential to be more efficient in treating the other organic compounds of concern. Granular activated carbon was also utilized during the treatability test to assess its performance in treating this water, and to serve as a back-up treatment to the U.V. system.

Another design consideration for the treatment system also relates to the potential for exposure to, and emissions of, volatilized organic compounds, especially vinyl chloride, which is particularly volatile. To reduce the likelihood of these problems occurring, the treatment system was designed as a completely closed, pressurized system from the well to the point of discharge of the fully treated water into the final collection tank.

4.2.1.2 Extraction System

Although the maximum design flow was determined to be 50 gpm, there existed the potential for Well UC22 to not be able to sustain that yield over the planned period of pumping without dewatering the well, since a pumping test at that rate had never been performed. Therefore, the treatment system and well pump were designed to operate over a wide range of potential flow rates: 10 to 50 gallons per minute. The well pump was also selected, and its elevation set in the well, to accommodate the potential range of drawdown from 45 feet to 119 feet. The selected submersible pump provided the maximum anticipated flow rate with adequate total dynamic

TABLE 4.2-1

Anticipated Influent Quality for the Treatability Test

<u>Volatile Organic Compound</u>	<u>Anticipated Concentrations (ug/l)</u>
1,1-Dichloroethane	7.5
1,1-Dichloroethene	<5.0
1,2-Dichloroethene	10.0
Tetrachloroethene	3000
Trichloroethene	30
1,1,1-Trichloroethane	30
Vinyl Chloride	20
<u>Metals</u>	
Arsenic	< 10 (total)
Chromium	< 160 (total)
Mercury	<0.35
Lead	< 18
Cadmium	<5.4
Copper	<51
Nickel	< 110

head to operate the system regardless of drawdown. The pump was fitted with a flow inducing sleeve to provide adequate cooling of the pump motor in the event that flow rates would have to be restricted to below 25 gpm (which is below the normal operating range of the pump). The well head was equipped with a pressure regulator and bypass loop to manage the potential wide range of pressures that would be developed by the pump depending upon the actual drawdown and flow rate experienced during the test.

4.2.1.3 Influent and Effluent Piping

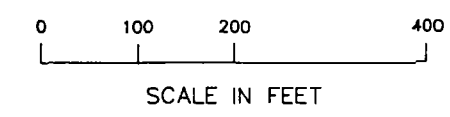
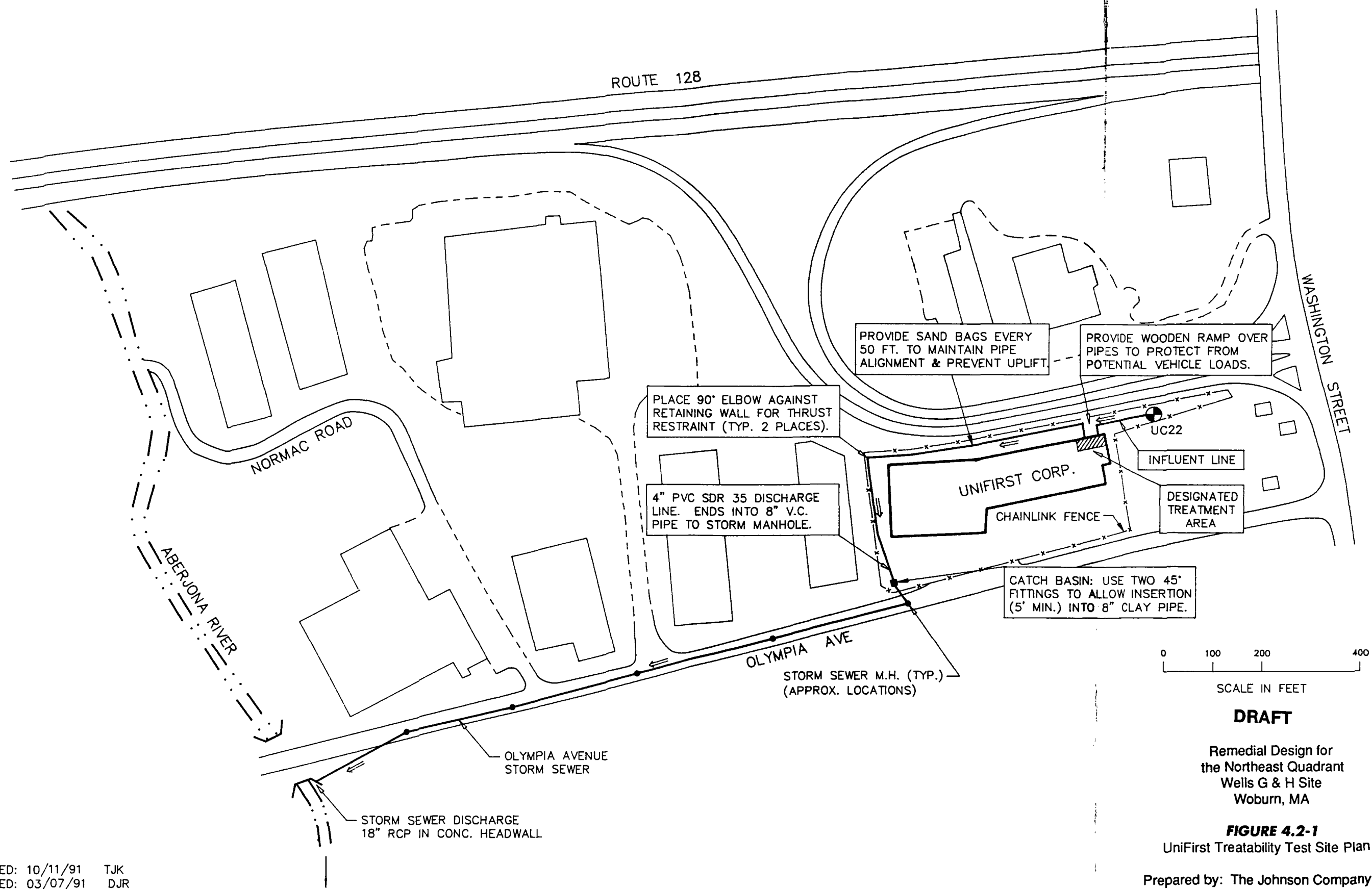
The influent and effluent pipes consisted of above-ground two-inch and four-inch PVC pipes, respectively. The UniFirst property piping layout is shown in Figure 4.2-1, Site Plan. The influent pipe was connected to the well drop pipe at the well head, and penetrated the exterior block wall at the UniFirst building to reach the treatment system.

The effluent pipe conveyed the treated water by gravity from the final collection tank, through the exterior block wall, and along the property fence line to a storm water catch basin at the southwest corner of the UniFirst property. The receiving storm sewer runs beneath Olympia Avenue to the Aberjona River.

4.2.1.4 Treatment Processes

The primary treatment system consisted of filtration, ultra violet/chemical oxidation (U.V.) and granular activated carbon (G.A.C.) designed for 50 gpm. In addition to the 50 gpm stream, side streams of 1 gpm and 12 gpm were directed through a reductive dehalogenation unit and a G.A.C. unit, respectively, for the purposes of obtaining additional treatability information. The effluent from the side stream treatment units were routed back to the main flow ahead of the U.V. system for full treatment. The piping and treatment equipment layout is shown in Figure 4.2-2. A description of the individual treatment units follows.

Filtration of any particulates or sediment in the influent was accomplished by a multi-media pressure filter which was installed at the front end of the treatment system. The filter used during this test was Model ML 30G, manufactured by Bruner Corporation of Milwaukee, Wisconsin. The manufacturer has indicated that this filter is capable of removing particulates down to a size of 10 microns. At 50 gpm the filter loading rate was approximately 10 gpm/ft². One of the filtration media is activated carbon which provided some inadvertent volatile organic removal via adsorption. Approximately 70 pounds of carbon is contained in the filter and it is likely the carbon was saturated early in the pump test.



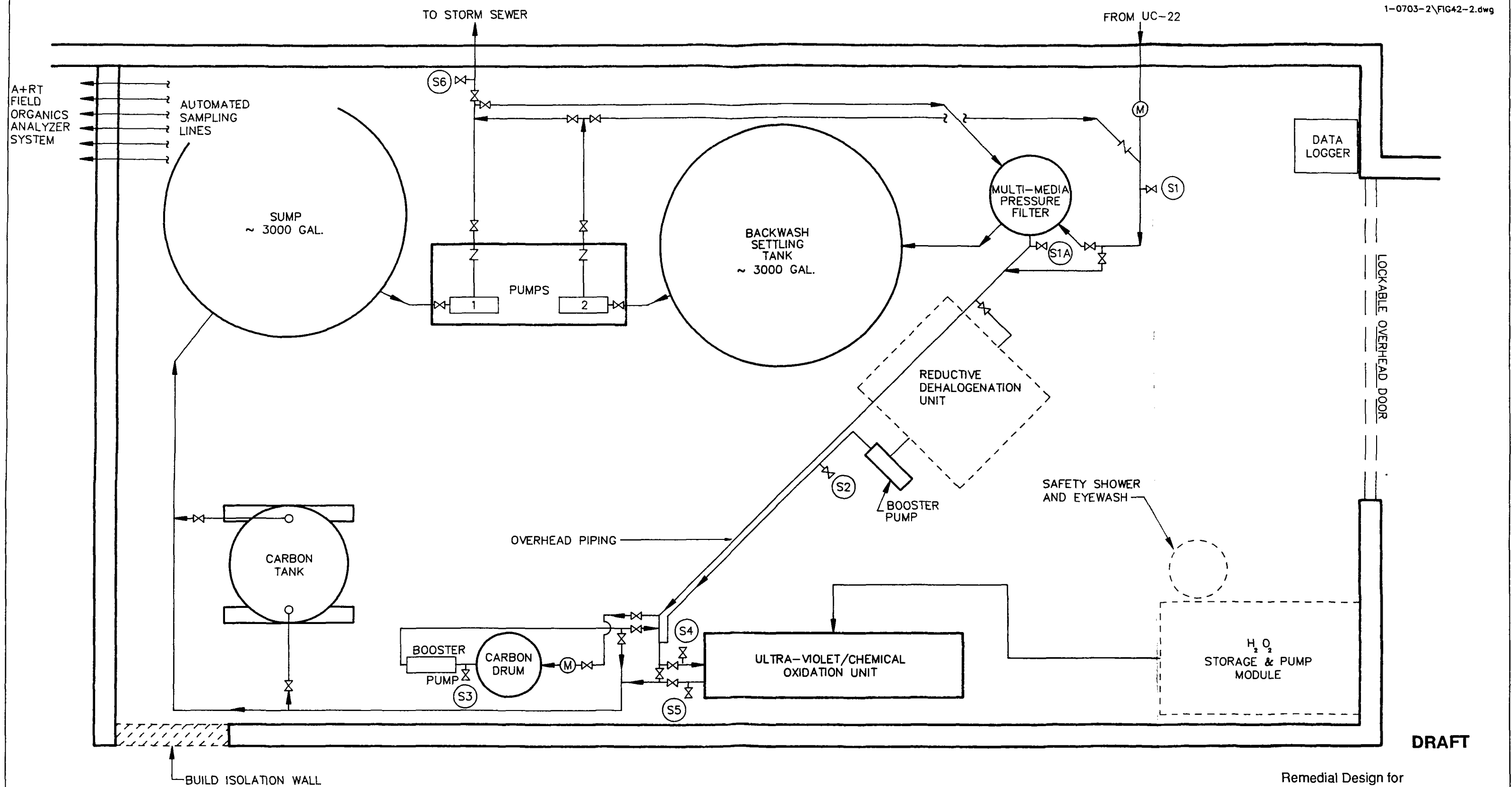
DRAFT

Remedial Design for
the Northeast Quadrant
Wells G & H Site
Woburn, MA

FIGURE 4.2-1
UniFirst Treatability Test Site Plan

Prepared by: The Johnson Company, Inc.

REVISED: 10/11/91 TJK
REVISED: 03/07/91 DJR
REVISED: 10/26/90 DJR
DRAWN: 05/23/90 TJK



DRAFT

Revised: 10/11/91 TJK
 Revised: 04/17/91 TJK
 Revised: 03/07/91 DJR
 Revised: 10/26/90 DJR
 Revised: 9/7/90 TJK
 Drawn: 5/23/90 TJK

LEGEND

(S1) SAMPLING PORT

⋈ BALL OR GLOBE VALVE

(M) FLOW METER

Z CHECK VALVE

0 1 2 3 6
 SCALE IN FEET

Remedial Design for
 the Northeast Quadrant
 Wells G & H Site
 Woburn, MA

FIGURE 4.2-2

UniFirst Treatability Test Site Piping
 Prepared by: The Johnson Company, Inc.

DRAFT

The main treatment process was ultra violet/chemical oxidation (U.V.). The unit used was model LVB-60 and the associated hydrogen peroxide module PM-000B manufactured by Peroxidation Systems, Inc., of Tucson, Arizona. This unit employs four 15 KW ultraviolet bulbs in a series of contact chambers that can provide a maximum contact time of 1.6 minutes at 50 gpm. The hydrogen peroxide module injects 50 percent hydrogen peroxide, the chemical oxidant used by this system, from a storage tank, into the oxidation chambers.

The final treatment process employed downstream of the U.V. unit was a G.A.C. unit. A Cansorb Model C-50 manufactured by Tigg Corporation was installed for this test. This G.A.C. unit contains 1650 pounds of virgin activated carbon and is designed for a maximum flow rate of 50 gpm. The carbon unit was employed to provide redundant treatment, as well as alternate treatment in the event of an upset condition with the U.V. unit or if the need arose to service the U.V. system during the test, allowing the pumping test to continue.

A 12 gpm side stream was directed through a TIGG Corp. Model C-15 carbon drum, which was fitted with sample ports at intermediate points within the bed of carbon to monitor contaminant breakthrough. This was done to allow an evaluation of carbon use and carbon bed size and configuration requirements in the event that carbon was selected as the primary treatment process for the final treatment system.

A 1 gpm side stream was directed through two experimental canisters containing a dehalogenation media being developed at the University of Waterloo. The purpose of this side train was to evaluate the potential of this media for use as a treatment method for this ground water. A more complete description of this media, the treatability test, and the results is presented in Section 4.2.4.2.4.

4.2.1.5 Control Systems

The treatment system controls are divided into two basic functions: 1) hydraulic control through the system, and 2) system upset response. The hydraulics of the system were controlled with a variety of valves, pressure regulators and pumps. A globe valve at the inlet to the treatment system was used to throttle flow to the desired rate, which was held constant through the test, while increasing drawdown in the well which influenced the output of the pump. The flow through each side train was similarly controlled by globe valves located on the discharge side of in-line booster pumps. Pressure regulators were employed to protect the treatment units from over-pressure. The regulators were also used to create different pressure zones within the system to facilitate adjustment of side train flows. Pressure gauges were installed at many points

in the system to monitor pressure changes during the test. The gauges were observed to monitor the multi-media filter and the carbon tank operation as well as other system pressures. Gauges were installed on the suction and discharge sides of the side train booster pumps to optimize the operation and assure a positive pressure within the treatment units.

Flow rate and drawdown were continuously monitored throughout the duration of the test. A paddle wheel type flow sensor (Model 228B by Data Industrial) was used in the system influent line and a pressure transducer (Model PCDR 830 by Druck) was installed in the well just above the submersible pump. The output of each sensor was recorded by a data logger on a predetermined scan interval of 15 minutes. The flow sensor also provided input to an electronic digital flow meter and totalizer. A mechanical flow meter was installed at the well head to provide backup in the event of electronic failure of the flow sensor and to obtain comparative flow data. The data logger was programmed to compare incoming flow and drawdown level data to set points and activate relays and a phone dialer if the set-point conditions occurred. For example, at a flow rate of 6 gpm or less, relays were energized that caused power interruption to the well and in-line booster pumps. This provision was included in the system to protect the pump in the event that a blockage was introduced in the piping system, e.g., an inadvertently closed valve. A phone dialer response was also programmed into the data logger which activated an automatic notification of system shutdown. Low level electrodes were installed in the well, 10 feet above the pump, to shutdown the well and booster pumps if this drawdown level was experienced, again, to protect the pumps. The phone dialer response would be activated in this scenario as well. If response to the notification was delayed, the system would still be shutdown by the low level electrodes. Other electrodes were tied into the data logger to provide notification in the event of high water in either the floor sump or the backwash settling tank. The U.V. unit was internally equipped with pressure, temperature and moisture sensors. Of these sensors, over-pressure and moisture were the ones potentially representing the most serious emergency conditions at the site and as such, were tied into the power interruption relay for the well and booster pumps. The remaining U.V. unit sensors monitoring internal conditions provided input to the data logger which would prompt a response to shutdown only the power to the U.V. unit, while allowing the well and booster pumps to continue operating, and relying on the carbon tank to provide primary treatment. The phone dialer would also be activated to provide notification of the U.V. system shut down.

4.2.1.6 Deviations from the Work Plan

The only substantive deviations from the Work Plan during the course of the treatability test were:

- 1) the use of an alternate preservative in some of the treatment system VOC samples,

- 2) exceedences of the laboratory turn-around times, and
- 3) a variation in the final testing and disposition of residual solids at the completion of the test.

A brief discussion of these deviations follows. All other provisions of the Work Plan were followed as they were originally presented.

Alternative Preservative

There was an initial concern that residual hydrogen peroxide in the effluent samples from the ultraviolet/chemical oxidation (U.V.) treatment unit could potentially continue to attack the chlorinated hydrocarbons during transport and storage of the samples. In response to this concern, effluent samples from the U.V. unit (sample location S5), and from final discharge from the treatment system (sample location S6), were preserved with ferrous ammonium sulfate, in addition to hydrochloric acid pursuant to EPA guidelines. The ferrous ammonium sulfate was intended to quench the effects of any residual hydrogen peroxide. However, during the first half of the treatability test, another concern was identified: that the introduction of ferrous ammonium sulfate into VOC sample vials may have the unintended side-effect of destroying chlorinated hydrocarbons. In order to eliminate any possibility of this occurrence, the ferrous ammonium sulfate was replaced with catalase as a preservative for quenching residual hydrogen peroxide.

A significant amount of data was produced using ferrous ammonium sulfate and hydrochloric acid, catalase and hydrochloric acid, and hydrochloric acid alone to indicate that the concerns regarding continuing destruction of organics were not significant as originally thought possible. Despite the variations in preservative use, the laboratory analytical data, in combination with the data made available from the A+ RT Field Organics Analyzer System, is completely sufficient to demonstrate the performance of the treatment units, as well as to show that discharge limits were easily met during the entire treatability test.

Laboratory Turn-Around

A significant number of the sample analyses did not meet the desired twenty-four hour turn-around for VOC analyses and the seventy-two hour turn-around for the metals analyses of the treatment system samples. Despite the laboratory turn-around time problem, the effluent data does indicate that at no time during the treatability test did the discharge quality approach the discharge limits. A specific discussion of compliance with discharge limits is presented in Section 4.2.4.1. Metals were not present in problematic concentrations in the influent as expected, so removal of metals through the treatment system was not required. Concentrations of VOC in the influent were about what were expected, and the treatment system, which was

designed to easily remove these compounds, performed completely successfully. The optimization of the U.V. system did not require quick turn-around time because operating conditions were varied to purposely bracket what we predicted to be optimum conditions. When the data was made available, an analysis was possible to determine the optimum UV exposure time and chemical dose. The results of this optimum testing are presented in Appendix L.

Testing and Disposition of Residual Solids

The Work Plan indicated that samples of carbon from the tank and drum and of the residual solids in the settling tank would be collected and analyzed for parameters that might identify the materials as hazardous waste. It is now intended to continue to utilize the remaining capacity of carbon in the tank in the final treatment system, and as a result this tank, with the partially expended carbon, has been drained and is stored at the UniFirst property. The carbon drum and the residual solids in the settling tank were of such a small volume, it was determined to be more cost effective to assume that these solids were hazardous waste, rather than analyzing them to prove that they were not hazardous. These solids will be removed from the UniFirst property and disposed of in accordance with RCRA requirements.

4.2.2 Operations

4.2.2.1 Start-up

Initially, the constructed treatment system was operated with municipal water on April 4, 1991 to check for hydraulic problems, operate valves and other equipment, and check the function of the electronic control components. This was accomplished successfully, and a few relatively minor adjustments and corrections were made. The final components of the well control system were then installed, and the well pump was started on April 11, 1991 and run for four hours, with the treatment system on line, for the purposes of confirming assumptions regarding influent quality, to check the mechanical components of the treatment system, and to tentatively evaluate the ability of the treatment system to meet the discharge limits. The treated water was collected in a tanker truck placed on the UniFirst property so that no discharge would occur during this start-up period until analytical results could be reviewed. At the end of the four hours of pumping the pressure drop across the multi-media filter had increased to an unacceptably high level (approximately 30 psi). After the well pump was turned off, the filter was backwashed, and the sediment-laden water was collected in the backwash tank where the suspended solids were allowed to settle out. During the four hours of pumping, samples of the influent and the effluent were collected at 2 1/2 hours, and at 4 hours (sample designations S1-1, S6-1, S1-2, and S6-2, respectively), preserved, recorded, and shipped to the laboratory for analysis.

The analytical results from the four-hour start-up pumping did not indicate any concern with the ability of the treatment system to produce water that would meet the discharge limits, nor did they indicate any concern with the previously assumed influent quality. As a result, EPA approval to go ahead with the 30-day pumping test was given. The analytical results from these samples are included in Appendix G.

The pump was started at 10:00 A.M. on April 30, 1991, and other than one unscheduled shutdown for 15 minutes on May 6 (described below), operated continuously until shutdown at 11:43 A.M. on May 30, 1991.

4.2.2.2 Monitoring Program

During the period of pumping and treatment plant operation, daily monitoring of the system was accomplished that included observing all flow meters, pressure gauges, temperature and U.V. lamp amp-meters, water levels in the tanks, generally observing the operation of the system, and visually inspecting the piping. These daily observations were recorded on operation logs, copies of which are included in Appendix H.

Also done on a daily basis was the collection of water quality samples from various locations in the treatment system, for the laboratory analysis of various analytes, in conformance with the Work Plan. Sampling logs were filled out for each sampling event, copies of which are included in Appendix I. Samples were collected from influent (S1) and effluent (S6) sample ports in the treatment system for analysis of the general groups of compounds indicated in Table 4.2-2. Also indicated on Table 4.2-2 is the sampling schedule.

In addition to collection of samples for laboratory analysis, volatile organic analyses were performed on site by the A+RT Field Organics Analyzer System, from various points in the treatment system. This system is more fully described in Section 4.2.3.2. The samples for these analyses were collected automatically through dedicated sample feed lines from the sample location at the treatment system piping, directly to the A+RT analytical system.

Field parameters were also monitored daily at the manual sample ports S1, S5 and S6 during the test. These field measurements included temperature, pH, and conductivity. The raw data from these measurements are shown on the sampling log forms in Appendix I. Hydrogen peroxide residual was also measured occasionally in the field with test strips (EM Quant Strips) at locations following the U.V. unit (S5), and at the effluent from the entire treatment system (S6).

Sampling Schedule for the UniFirst Treatability Test: Influent and Effluent

[illegible]

TABLE 4.2-2 (cont.)

Sample	Day	Sample Location	VOC	TSS	Field Parameters	Radionuclides	Cr+6	SVOC	PCB/ Pesticides	TDS/ Alkalinity	Metals	Cyanide	Major Ions	Iron	Manganese
S6	5	Final Effluent	X		X						X				
S6	6	Final Effluent	X		X										
S6	7	Final Effluent	X		X						X				
S6	8	Final Effluent	X		X										
S6	9	Final Effluent	X		X										
S6	10	Final Effluent	X		X			X							
S6	11	Final Effluent	X		X										
S6	12	Final Effluent	X		X										
S6	13	Final Effluent	X		X										
S6	14	Final Effluent	X	X	X	X	X	X	X	X	X	X	X		
S6	15	Final Effluent	X		X										
S6	16	Final Effluent	X		X										
S6	17	Final Effluent	X		X										
S6	18	Final Effluent	X		X										
S6	19	Final Effluent	X		X										
S6	20	Final Effluent	X		X										
S6	21	Final Effluent	X	X	X	X	X	X	X	X	X	X	X		
S6	22	Final Effluent	X		X										
S6	23	Final Effluent	X		X										
S6	24	Final Effluent	X		X										
S6	25	Final Effluent	X		X										
S6	26	Final Effluent	X		X										
S6	27	Final Effluent	X		X										
S6	28	Final Effluent	X		X										
S6	29	Final Effluent	X	X	X	X	X	X	X	X	X	X	X		
S6	30	Final Effluent	X		X										
S6	31	Final Effluent	X		X										

VOC = Volatile organic compounds

TSS = Total suspended solids

Cr+6 = Hexavalent chromium

SVOC = Semi-volatile organic compounds

PCB = Polychlorinated biphenyls

TDS = Total dissolved solids

4.2.2.3 Operating Conditions

As with any mechanical system and treatability test, all operating conditions are not routine. Periodically during this test, unique events occurred, up-set conditions were experienced, and adjustments and/or changes to the system or the operational pattern were made. A summary of the most significant non-routine operational events is presented in Table 4.2-3.

The UC22 well was equipped with a pressure transducer and the influent piping included an electronic flow meter, both of which were tied into a data logger, which was on line for the duration of the 30-day test. Plots of flow rate and water level elevation during the test are shown in Figures 4.2-3 and 4.2-4. As can be seen in Figure 4.2-3, the flow rate was maintained at 50 gpm continuously for the entire test with the exception of two points in time. The first point was during day 1 of pumping. At 20:45 on April 30, 1991 (elapsed pumping time of 640 minutes) the flow meter was observed as indicating 26 gpm. The main influent throttling valve was opened enough to bring the flow rate back up to 50 gpm, where it was easily maintained throughout the remainder of the test. It is not known why at one point in the test the flow rate dropped significantly. The other point in time when the flow rate was not maintained at 50 gpm was on day 7 of pumping (May 6, 1991), when the pump was shut down at 10:30 (elapsed time of 8665 minutes) for approximately 15 minutes due to moisture detected in one of the lamp enclosure units.

The water level readings (Figure 4.2-4) indicated a relatively traditional response to pumping conditions, with a rapid initial drawdown followed by steadily decreasing water levels. The two points in time when flow was not maintained at 50 gpm (as described above) are reflected in the water elevation measurements for those times (elapsed times of 640 and 8665 minutes)

4.2.2.4 Decommissioning

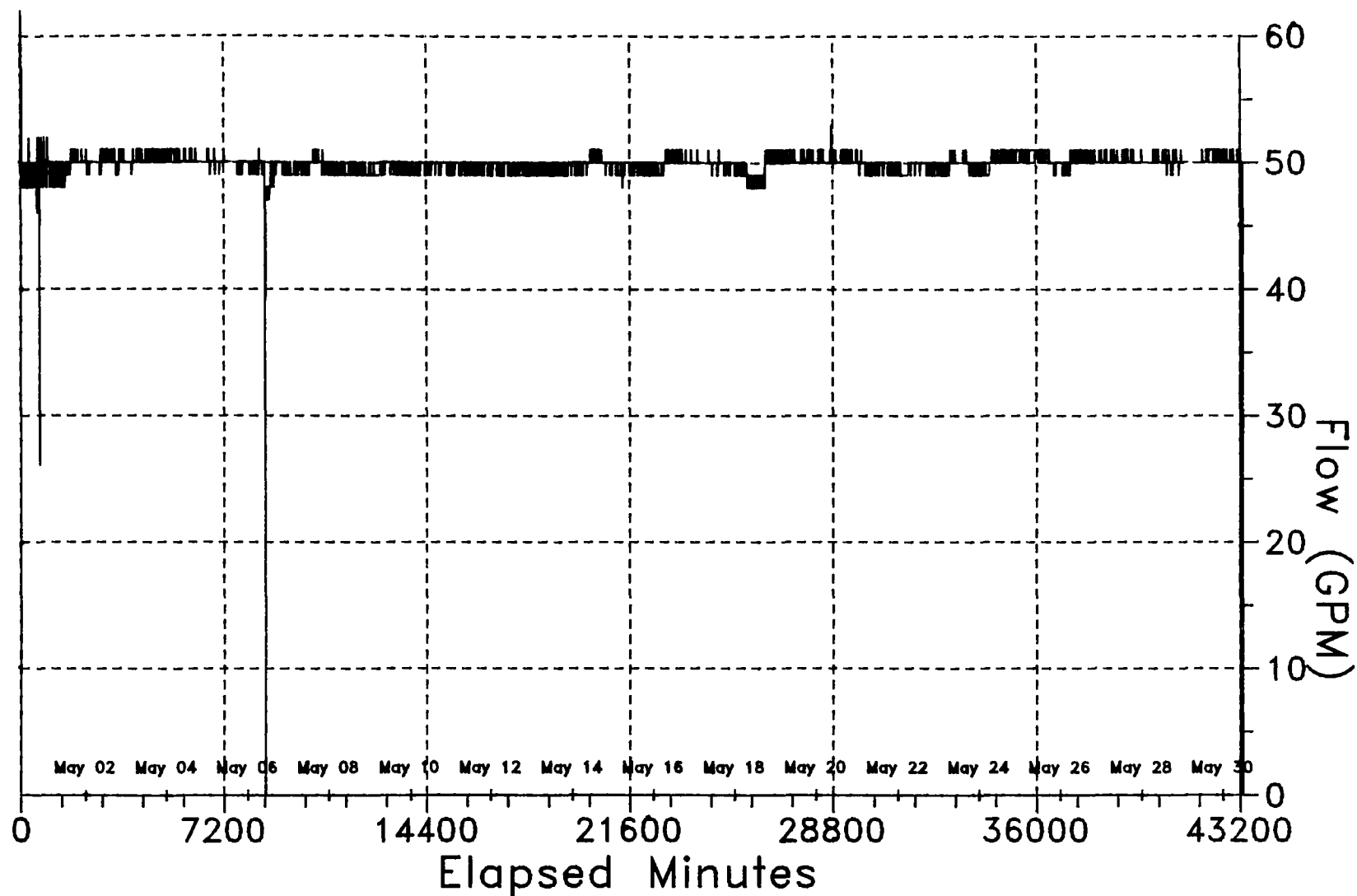
The pumping test was terminated on May 30, 1991. Prior to shutting the well pump down, settled water from the backwash settling tank was reinjected into the front end of the treatment system. The water was a result of the previous carbon tank backwash and water generated during system sampling procedures. The reinjection of the water to the low level shut-off (18-inches off the floor of the tank) was completed by 11:00 A.M. The well pump was shut down at 11:45 A.M. The reductive dehalogenation columns were drained into the floor sump and pumped into the backwash settling tank. The main treatment system piping was also partially drained into the settling tank. The influent and effluent pipes to the reductive dehalogenation unit were cut and capped.

TABLE 4.2-3

Operational Events During the Treatability Test

<u>Date</u>	<u>Event</u>
4/30/91	Start pumping test, began using ferrous ammonium sulfate in addition to hydrochloric acid in VOC samples as preservative in S5 and S6 samples.
4/30/91 (20:45)	Adjusted valve G-1 to bring flow from 26 gpm to 50 gpm
5/3/91 (6:35)	Backwashed carbon tank
5/4/91 (18:14)	U.V. unit power shut down somewhere between 07:00 and 07:45 due to lack of H ₂ O ₂ feed pressure
5/6/91	H ₂ O ₂ feed pressure problem fixed and U.V. power turned back on
5/6/91 (approx. 10:30)	Power to well pump in UC22 shut down due to moisture in U.V. bulb enclosure
5/6/91 (approx. 10:45)	Bulb enclosure moisture sensor override was accomplished and power restored to the well pump. Treatment was provided by the carbon tank until the UV unit was repaired and back on line
5/6/91	Bulb enclosure replaced and U.V. unit put back on line
5/8/91	Peroxide feed module air locked, line purged and reprimed.
5/14/91	Backwashed carbon tank, ended using ferrous ammonium sulfate in addition to hydrochloric acid as preservative in S5 and S6 VOC samples and switched to just hydrochloric acid.
5/18/91	Started using catalase in addition to hydrochloric acid as preservative for S5 and S6 VOC samples for duration of treatability test.
5/18/91	Peroxide feed module air locked, line purged and reprimed.
5/20/91 (10:05)	Backwashed carbon tank
5/20/91 (11:35-15:14)	U.V. unit by-passed for tube cleaning in anticipation of optimization testing.
5/21/91	Optimization tests performed on U.V. unit (contact time and H ₂ O ₂ doses varied)
5/22/91	Power to U.V. unit shut down sometime after 5/21/91, 18:06 (time of previous inspection) due to H ₂ O ₂ low pressure. Problem was resolved by 5/22/91, 06:30, and system back to normal operation.
5/30/91 (11:43)	Well pump (UC22) turned off and treatability test terminated.

4-16



— Flow measurements recorded from Campbell Data Logger

The Johnson Company, Inc.

FIGURE 4.2-3

Treatability Test Flow Rate (gpm)

DRAFT

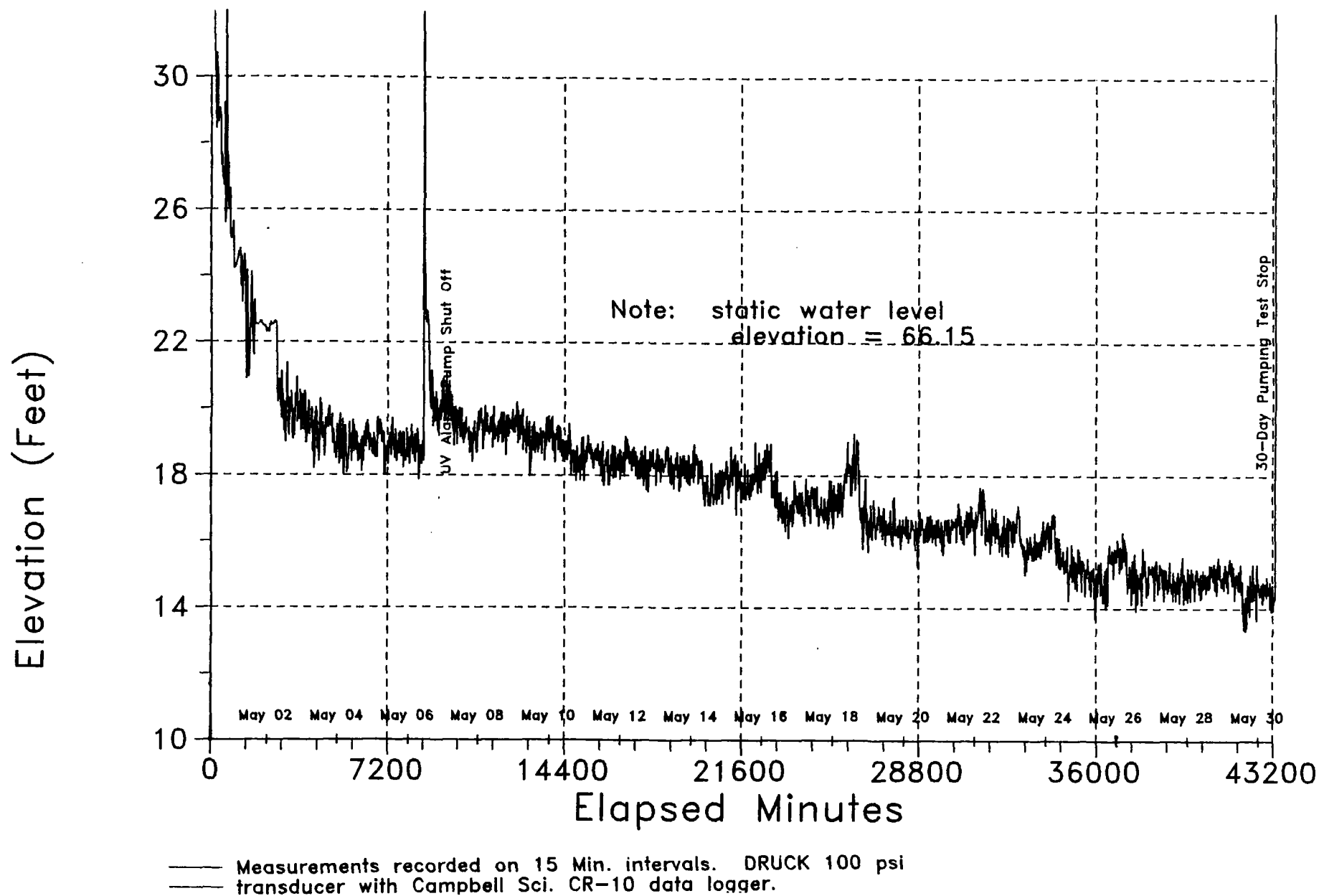


FIGURE 4.2-4

UC22 Water Level Elevations

The side train carbon drum piping was isolated by valves in the system. The drum itself was also isolated by valves. The piping was drained into the floor sump and then dismantled. Both side train booster pumps were dismounted, drained and flushed. All water resulting was directed into the floor sump and pumped into the settling tank. The pumps and dismantled piping were stored on site. The carbon drum inlet and outlet were plugged to allow removal of the drum and contents.

The portable pump used during the test for carbon tank backwash was used to empty approximately forty 55-gallon drums of water stored on the UniFirst property. The majority of the water was purge water generated from sampling area monitoring wells. Six of the drums contained appreciable solids, thought to be grout. These drums contained the water resulting from well UC23 development.

Workers wearing full-face respirators and nitrile gloves pumped the contents of the drums into the backwash settling tank. The drums containing the grout were pumped free of overlying liquid, which was also discharged into the backwash settling tank.

On May 31, 1991, the supernatant in the settling tank was reinjected into the treatment system. The water was pumped through the large carbon tank at a rate of approximately 3 gpm. The lengthy contact time in the carbon tank assured adequate treatment. It took approximately 5 hours to reinject the water down to the low level shut-off. Upon completion of the reinjection the multi-media filter was backwashed. Initially the backwash water was very dirty (much of the solids from the drums) but was clear at the end of the 15-minute backwash period. The portable pump was connected to backwash the carbon tank. The backwash water appeared free of solids. The portable pump did not provide as much flow as it had during earlier backwash events. It is presumed that pumping the contents of the drums containing rust, sand, and grout had a detrimental effect on the pump's performance. The flow rate provided by the pump may not have been great enough to fully expand the carbon bed and dislodge all of the particulates. Prior to use of this carbon tank in the final system a complete and adequate backwash will be performed.

On June 6, 1991, additional decommissioning tasks were performed including the removal of all above-ground exterior piping and conduit. First, the settled backwash generated during the previous visit was reinjected. The influent line from the well was isolated inside the treatment room by closing the control valve. A 2-inch hose was connected at the exterior and the influent line drained into buckets, which in turn were dumped into the settling tank for reinjection. The power to the data logger, well pump and low level electrodes was shut off. Wearing protective

gear, the pressure transducer was pulled from the well, along with its protective casing. Surface conduits and wires were dismantled and stored for future use. The pressure transducer cable was washed with soapy water and rinsed, coiled and stored.

A 2-inch hose was connected between the exterior influent and effluent line connections. The backwash pump was used to circulate previously treated water from the final collection tank back through the system, essentially displacing all residual water in the system and forcing it through the carbon tank. The water was pumped through this closed loop at 42 gpm for approximately 2 hours. At this time it was presumed that any contaminated water in the system piping or units had been displaced and treated.

The piping and treatment units upstream of the carbon tank were then drained and discharged. The sump pump was lowered by rope into the back wash settling tank. The pump discharge was fitted with a 3/4-inch hose and connected to the carbon tank. The supernatant was pumped through the carbon drum down to about a 3-inch depth, which was primarily settled sludge. The pump was then retrieved and set in a bucket. A hose connected to the municipal waterline continually supplied water to flush the pump and discharge hose until clean. The UniFirst property was secured as workers left for the day.

On June 7, 1991, a hose was connected from the municipal water system to upstream of the carbon tank. The city water displaced water in the tank and associated influent piping at approximately 10 gpm for 2 hours, with the treated effluent being discharged to the storm sewer. At the end of the flushing period the remaining water was drained into the floor sump and pumped to discharge. The sump pump was then lowered into the final collection tank to pump and discharge the remaining 6 inches of water.

Samples of residual solids were then collected. The sludge in the bottom of the settling tank was collected using a plastic container with a rectangular opening attached to a rope. Samples were collected for VOC, metals and radionuclide analysis. Enough sludge was collected for 2 samples of each analyte class.

The contents of the six drums, thought to be grout, were also sampled. A piece of 1-inch polyethylene pipe was fabricated into a sampling tool. Contents of the drums were composited into sample containers, 2 each for VOC, metals and radionuclide analysis.

The samples were packed in a cooler with ice, and chain-of-custody forms were filled out. The samples were ultimately delivered to the contract lab via courier.

Once the sampling was completed the 4-inch PVC discharge line from the treatment system was dismantled. The pipe was stored adjacent to the treatment room for potential future use. Decontamination of this piping was not necessary since it never came in contact with contaminants.

4.2.2.5 Health and Safety

As discussed earlier, the treatment system at UniFirst was a completely closed, pressurized system, which greatly reduced the possibility of VOC off-gasing. Furthermore, vinyl chloride, the most volatile of the potential contaminants was not detected in any of the UniFirst ground-water samples. There were, however, isolated instances when there was potential exposure to contaminated water. The air in the breathing zone was monitored using photoionization detection devices. The devices used were either a model #PI 101 by HNP Systems, Inc. or model # 580-B, O.V.M. by Thermo Environmental Instruments. Prior to use, the instruments were calibrated with span gas using standard procedures.

The air at the well head was monitored prior to the installation of the pressure transducers and protective casing, and there was no detection of VOC. During start-up of the reductive dehalogenation unit, a leak at the inlet to the unit became apparent. An isolation valve was closed and the air in the immediate area of the leak was monitored. There was no detection of VOC and the leak was fixed by tightening a fitting. The repair work was performed wearing gloves and safety glasses, while there was no pressure on the fitting being repaired.

Upon completion of the 30-day test, drums of purge water were pumped from into the settling tank. As each drum was opened, the air inside was monitored. Some drums had initial readings of between 20 and 30 ppm. In all cases, the levels dissipated quickly. Although it is quite likely that levels in the breathing zone were not as high as the air in the closed drum, full face respirators with appropriate cartridges in accordance with the Health and Safety Plan were worn as a safety precaution.

When decommissioning the treatment system the air was regularly monitored when collecting non-treated water. Only slight readings (below 1 ppm) were detected. Gloves and safety glasses were worn to prevent contact due to possible splashing.

When pulling the pressure transducer from the well, the air at the well head was monitored with no detection of VOC. Appropriate personal protective gear was worn to prevent possible contact with contaminated water.

From the initial treatment system testing in mid-April, through the completion of the pumping test and system decommissioning there were no health or safety incidents. Similarly, there were no exposures to, or the need to handle the 50 percent hydrogen peroxide solution, throughout the duration of the test.

4.2.3 Analytical Results

4.2.3.1 Summary

The analytical results from laboratory analyses of the treatability samples have been organized into the main categories of compounds listed in Table 4.2-2. The analytical laboratory results are included in Appendix G.

The data from the A+RT Field Organics Analyzer System for volatile organic compounds is presented in the report prepared specifically for that demonstration project, which is included in Appendix J. A summary description of that demonstration project is presented in Section 4.2.3.2.

4.2.3.2 A+RT Automated Volatile Organics Analysis System

Figure 2-5 from the Work Plan (EPC, 1991) illustrates the layout of the A+RT automated volatile organics analysis system (AVOAS) and the treatment-system-sampling ports to which the analyzer was directly piped. The AVOAS was "hard plumbed" to the sampling ports of the pilot treatment plant to provide a means of testing the AVOAS' ability to automatically sample and analyze aliquots of influent, process and effluent water from the treatment system. In addition, A+RT constructed the AVOAS with manual injection ports. The purpose of this technology demonstration was to provide a full-scale field-assessment of the practicality of installing an automatically operated field gas-chromatograph that would provide data of high enough quality to be acceptable by the EPA for long-term operation of the treatment plant and ground-water monitoring. Should the demonstration prove to be successful UniFirst, Grace and the EPA would be provided with a highly cost effective alternative for producing operational data from the permanent treatment systems and analytical data from ground-water samples.

The AVOAS consisted of six parts: 1) the sampling manifold; 2) the injector (a purge and trap unit); 3) the gas chromatograph; 4) a Hall detector; 5) the integrater; and 6) the computer. The first two items were custom built by A+RT. The rest of the equipment are off-the-shelf items supplied by other equipment manufacturers. The software for the computer that runs the system is written by A+RT. In this configuration the A+RT AVOAS performs analysis for which the most relevant standard operating procedure is EPA method 502.2. Prior to this implementation, the

A+RT device had been successfully operated in the lab and at several other sites in the western United States. Appendix J contains the Analyst's Summary for the Evaluation Study and a disk of the data produced during the Study.

The equipment operated on-site from April 13, 1991 through April 30, 1991. Through its period of operation, the AVOAS automatically sampled and analyzed aliquots from the treatment system over night. Through the days, the AVOAS was used primarily for manual injection of ground-water samples, treatment plant samples from the Grace pilot plant and a large set of performance evaluation and practical quantitation limit samples provided by EPA's Environmental Monitoring Systems Laboratory-Las Vegas (EMSL-LV).

During the operation of the AVOAS, staff from EMSL-LV conducted an evaluation under the Superfund Innovative Technology Evaluation (SITE) program. The preliminary results of the EMSL-LV evaluation was reported in a July 1991 EMSL-LV Technology Support Project news release. This report describes the A+RT AVOAS "to be reliable and easy to use. Comparisons of data from the AVOAS study with standard analytical laboratory results from sample splits indicate a strong correlation. The AVOAS results were consistently higher, perhaps reflecting differences due to sample loss during transport." EMSL-LV hopes to release a draft Technology Evaluation Report in November 1991.

4.2.3.3 Influent Characterization

The influent quality was fully characterized by the collection of samples from the influent pipe to the multimedia filter (sample location S1) on days indicated and analyzed for compounds shown in Table 4.2-2.

Influent sample (S1) results for some of the groups of compounds listed in Table 4.2-2 have been summarized in the following tables:

Influent Volatile Organic Compounds -Laboratory Results: Table 4.2-4

Influent Volatile Organic Compounds-A+RT Field Organics Analyzer System Results:
Table 4.2-5

Influent Inorganics: Table 4.2-6

Influent and Effluent Radionuclides: Table 4.2-7

Influent Physical Parameters and Field Measurements: Table 4.2-8

Semi-volatile organics and Pesticides/PCB have not been summarized in tables for the text of this report because none of these compounds were detected by the laboratory. The reported analytical laboratory results indicating the detection limits for these compounds are included in Appendix G.

TABLE 4.2-4

Influent Volatile Organic Compounds - Laboratory Results (µg/L)

Sample Name	Sample Number	Sample Date	1,1-dichloro ethane	1,1-dichloro ethene	1,2-dichloro ethene	Tetrachloro ethene	Trichloro ethene	1,1,1-tri chloroethane
S1	1	4/11	<5.0	<5.0	<5.0	13.0	<5.0	<5.0
S1	2	4/11	<5.0	<5.0	<5.0	17.0	<5.0	<5.0
S1	3	4/30	<5.0	<5.0	<5.0	26.0	J4.0	<5.0
S1	4	5/01	<12.0	<12.0	<12.0	280.0	J11.0	<12.0
S1	5	5/02	<25.0	<25.0	<25.0	750.0	R	<25.0
S1	6	5/03	<50.0	<50.0	<50.0	1300.0	<50.0	<50.0
S1	7	5/04	<62.0	<62.0	<62.0	1600.0	<62.0	<62.0
S1	8	5/05	<62.0	<62.0	<62.0	1900.0	<62.0	<62.0
S1	9	5/06	<62.0	<62.0	<62.0	2200.0	R	<62.0
S1	10	5/07	<62.0	<62.0	<62.0	2200.0	<62.0	<62.0
S1	11	5/08	<100.0	<100.0	<100.0	2400.0	<100.0	<100.0
S1	12	5/09	<100.0	<100.0	<100.0	2700.0	<100.0	<100.0
S1	13	5/10	<100.0	<100.0	<100.0	3000.0	<100.0	<100.0
S1	14	5/11	<100.0	<100.0	<100.0	3100.0	<100.0	<100.0
S1	15	5/12	<100.0	<100.0	<100.0	2600.0	<100.0	<100.0
S1	16	5/13	<100.0	<100.0	<100.0	3500.0	<100.0	<100.0
S1	17	5/14	<100.0	<100.0	<100.0	3100.0	<100.0	<100.0
S1	18	5/15	<100.0	<100.0	<100.0	3200.0	<100.0	<100.0
S1	19	5/16	<100.0	<100.0	<100.0	3900.0	<100.0	<100.0
S1	20	5/17	<100.0	<100.0	<100.0	3300.0	<100.0	<100.0
S1	21	5/18	<100.0	<100.0	<100.0	3300.0	J78.0	<100.0
S1	22	5/19	<100.0	<100.0	<100.0	3300.0	<100.0	<100.0
S1	23	5/20	<100.0	<100.0	<100.0	3500.0	J85.0	<100.0
S1	24	5/21	<100.0	<100.0	<100.0	3400.0	J80.0	<100.0
S1	25	5/22	<100.0	<100.0	<100.0	3700.0	J87.0	<100.0
S1	26	5/23	<100.0	<100.0	<100.0	3900.0	J97.0	<100.0
S1	27	5/24	<100.0	<100.0	<100.0	3600.0	J92.0	<100.0
S1	28	5/25	<100.0	<100.0	<100.0	3800.0	J110.0	<100.0
S1	29	5/26	<100.0	<100.0	<100.0	3900.0	J99.0	R
S1	30	5/27	<100.0	<100.0	<100.0	4000.0	J110.0	J130.0
S1	31	5/28	<100.0	<100.0	<100.0	4100.0	110.0	<100.0
S1	32	5/29	<100.0	<100.0	<100.0	4400.0	110.0	<100.0
S1	33	5/30	<100.0	<100.0	<100.0	4000.0	120.0	<100.0

NOTES: "J" indicates that concentrations below detection limits were observed.

"R" indicates that the data was rejected by the data validator.

TABLE 4.2-5

**Influent Volatile Organic Compounds
A+RT Field Organics Analyzer System Results (µg/L)**

Sample Name	elapDate in May	Vinyl Chloride	1,1-dichloro ethene	T-DCE	1,1-dichloro ethane	C-DCE	1,2-dichloro ethane	Trichloro ethane	Trichloro ethene	Tetrachloro ethene
S1	16.0	0.00	11.3	0.0	4.2	14.0	0.00	33.3	65.0	3886
S1	17.2	0.00	7.4	0.0	3.6	15.3	0.00	31.4	61.5	3444
S1	17.7	0.00	7.4	0.0	4.4	16.9	0.00	36.4	75.5	4065
S1	18.3	0.00	9.8	0.0	3.7	17.2	0.00	30.3	69.8	3830
S1	18.9	0.00	9.8	1.1	4.3	17.6	0.00	37.1	73.6	3809
S1	19.1	0.00	9.7	0.0	3.5	17.5	0.00	35.2	70.8	3730
S1	19.9	0.00	12.1	.7	3.4	21.3	0.00	37.7	81.5	3875
S1	20.2	0.00	7.8	0.0	4.0	19.2	0.00	37.8	78.4	4027
S1	20.9	0.00	11.3	0.0	3.5	18.8	0.00	33.3	71.7	3582
S1	21.1	0.00	7.7	0.0	3.6	19.0	0.00	33.8	72.0	3706
S1	22.0	0.00	10.6	0.0	3.8	19.1	0.00	36.2	78.3	4058
S1	22.2	0.00	9.9	0.0	4.0	18.7	0.00	33.7	76.6	3843
S1	22.9	0.00	8.2	0.0	3.3	17.7	0.00	32.4	73.3	3730
S1	23.1	0.00	7.4	0.0	3.5	19.4	0.00	39.1	81.8	3766
S1	24.4	0.00	4.2	0.0	3.8	23.3	0.00	46.7	102.0	4856
S1	25.4	0.00	5.6	0.0	4.4	23.2	0.00	46.1	102.3	5083
S1	25.9	0.00	5.2	0.0	5.1	22.2	0.00	37.9	94.1	4983
S1	26.9	1.30	8.5	0.0	4.7	26.4	0.00	35.9	95.2	4304
S1	27.3	0.00	6.8	0.0	4.7	22.7	0.00	36.3	89.2	4189
S1	27.7	0.00	7.3	0.0	4.6	22.9	0.00	31.6	84.9	3975
S1	28.0	0.00	11.4	0.0	3.3	36.3	1.20	36.4	129.1	5294
S1	28.5	0.00	9.2	.6	4.2	21.0	0.00	26.1	71.7	
S1	28.6	0.00	10.6	1.3	2.7	19.5	0.00	29.2	83.8	3645
S1	28.9	0.00	12.2	0.0	2.7	18.0	0.00	29.4	79.7	3390
S1	29.2	0.00	9.1	0.0	2.3	16.9	0.00	27.8	78.2	3502
S1	29.5	0.00	7.6	0.0	2.7	19.6	0.00	31.1	91.4	4012
S1	29.7	0.00	5.7	0.0	2.8	16.9	0.00	28.5	81.2	3660
S1	30.0	0.00	6.1	0.0	2.0	16.4	0.00	25.6	77.5	3543
S1	30.3	0.00	5.2	0.0	2.0	17.4	0.00	27.6	80.5	3641

elapDate in May = sample date and time where time is represented by a decimal fraction
(e.g., 17.69 = May 17, 4:05 P.M.)

t-DCE = trans-1,2,-dichloroethene

c-DCE = cis-1,2-dichloroethene

TABLE 4.2-6

Influent Inorganic Laboratory Results (µg/l)

Sample Name	Sample Number	Sample Date	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium (Total)	Chromium (Hexavalent)	Cobalt
S1	3	4/30	< 195.	< 1.00	< 1.0	J 23.0	< 1.0	< 3.0	86200	J10.0		< 6.0
S1	5	5/02	< 195.	< 1.00	< 1.0	J 22.0	< 1.0	< 3.0	86400	<10.0		< 6.0
S1	7	5/04	< 195.	< 3.00	< 1.0	J 16.0	< 1.0	< 3.0	83500	<10.0		< 6.0
S1	9	5/06	< 195.	< 1.00	< 1.0	J 19.0	< 1.0	< 3.0	88100	<10.0		< 6.0
S1	11	5/08	< 195.	< 1.00	< 1.0	J 16.0	< 1.0	< 3.0	86200	<10.0		< 6.0
S1	16	5/13	< 195.	< 1.00	< 1.0	J 17.0	< 1.0	< 3.0	87800	<10.0	R 0	< 6.0
S1	23	5/20	< 195.	< 1.00	< 1.0	J 17.0	< 1.0	< 3.0	90500	<10.0	< 0	< 6.0
S1	31	5/28	< 195.	< 1.00	< 1.0	J 17.0	< 1.0	< 3.0	88400	<10.0	< 0	< 6.0
S1 FB	3	4/30	< 195.	< 1.00	< 1.0	J 13.0	< 1.0	< 3.0	< 448	J10.0		< 6.0
S1 FB	5	5/02	< 195.	< 1.00	< 1.0	< 13.0	< 1.0	< 3.0	< 448	J10.0		< 6.0
S1 FB	7	5/04	< 195.	< 3.00	< 1.0	J 13.0	< 1.0	< 3.0	607	<10.0		< 6.0
S1 FB	9	5/06	< 195.	< 1.00	< 1.0	J 13.0	< 1.0	< 3.0	< 448	J10.0		< 6.0
S1 FB	11	5/08	< 195.	< 1.00	< 1.0	R	< 1.0	< 3.0	< 448	J10.0		< 6.0
S1 FB	16	5/13	< 195.	< 1.00	< 1.0	R	< 1.0	< 3.0	< 448	J10.0	R 0	< 6.0
S1 FB	23	5/20	< 195.	< 1.00	< 1.0	< 13.0	< 1.0	< 3.0	J 3	<10.0	< 0	< 6.0
S1 FB	31	5/28	< 195.	< 1.00	< 1.0	R	< 1.0	< 3.0	< 448	<10.0	< 0	< 6.0

NOTES: "J" indicates that concentrations below detection limits were observed.
 "R" indicates that the data was rejected by the data validator.

TABLE 4.2-6 (cont.)

Sample Name	Sample Number	Sample Date	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium
S1	3	4/30	11.0	204.0	J 2.0	12200	28.0	<0.00	< 9.0	3580	< 1.00	J 8.0	139000
S1	5	5/02	<11.0	J243.0	J 3.0	11000	30.0	<0.00	< 9.0	3000	< 1.00	J 10.0	111000
S1	7	5/04	5.0	< 98.0	< 1.0	10400	< 2.0	<0.00	< 9.0	2460	< 1.00	J 8.0	96800
S1	9	5/06	7.0	< 98.0	1.0	10900	< 2.0	<0.00	< 9.0	3060	< 1.00	< 8.0	97700
S1	11	5/08	6.0	< 98.0	< 1.0	10300	< 2.0	<0.00	< 9.0	2350	< 1.00	J 8.0	86700
S1	16	5/13	< 8.0	< 98.0	< 1.0	10300	< 2.0	<0.00	< 9.0	2640	< 1.00	J 11.0	78100
S1	23	5/20	10.0	215.0	J 1.0	10700	< 2.0	<0.00	< 9.0	2570	< 1.00	< 8.0	76600
S1	31	5/28	< 6.0	J131.0	< 1.0	10300	< 3.0	<0.00	< 9.0	2650	< 1.00	J 24.0	73000
S1 FB	3	4/30	< 5.0	< 98.0	J 1.0	< 509	< 2.0	<0.00	< 9.0	< 760	< 1.00	J 8.0	< 390
S1 FB	5	5/02	< 5.0	133.0	< 1.0	< 509	< 2.0	<0.00	< 9.0	< 760	< 1.00	J 8.0	< 390
S1 FB	7	5/04	< 5.0	< 98.0	< 1.0	< 509	< 2.0	<0.00	< 9.0	< 760	< 1.00	J 8.0	767
S1 FB	9	5/06	< 5.0	< 98.0	< 1.0	< 509	< 2.0	<0.00	< 9.0	< 760	< 1.00	J 8.0	< 390
S1 FB	11	5/08	< 5.0	140.0	1.0	< 509	< 2.0	<0.00	< 9.0	< 760	< 1.00	< 8.0	< 390
S1 FB	16	5/13	7.0	133.0	1.0	< 509	< 2.0	<0.00	< 9.0	< 760	< 1.00	J 8.0	< 390
S1 FB	23	5/20	< 5.0	< 98.0	< 1.0	< 509	< 2.0	<0.00	< 9.0	< 760	< 1.00	< 8.0	< 390
S1 FB	31	5/28	5.0	277.0	< 1.0	< 509	2.0	<0.00	< 9.0	< 760	< 1.00	J 14.0	526

TABLE 4.2-6 (cont.)

Sample Name	Sample Number	Sample Date	Thallium	Vanadium	Zinc	Cyanide	Total Phosphorous	Chloride	Fluoride	NO2-NO3	Dissolved Silica	Sulfate
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
S1	3	4/30	< 1.0	< 4.0	272.0							
S1	5	5/02	< 1.0	< 4.0	193.0							
S1	7	5/04	< 1.0	< 4.0	J146.0							
S1	9	5/06	< 1.0	< 4.0	J243.0							
S1	11	5/08	< 1.0	5.0	122.0							
S1	16	5/13	< 1.0	< 4.0	<115.0	< 10	< 0.000	261.00	< 0.0	3.100	11.7	J30.3
S1	23	5/20	< 1.0	J 4.0	<122.0	< 10	< 0.000	J249.00	< 0.0	3.000	11.3	J32.6
S1	31	5/28	< 1.0	J 6.0	<132.0	< 10	< 0.000	242.00	< 0.0	3.400	11.2	J29.8
S1 FB	3	4/30	< 1.0	< 4.0	23.0							
S1 FB	5	5/02	< 1.0	< 4.0	10.0							
S1 FB	7	5/04	< 1.0	< 4.0	J 34.0							
S1 FB	9	5/06	< 1.0	< 4.0	J 25.0							
S1 FB	11	5/08	< 1.0	< 4.0	19.0							
S1 FB	16	5/13	< 1.0	< 4.0	29.0	< 10	.070	< 1.00	< 0.0	.070	5.4	J 5.0
S1 FB	23	5/20	< 1.0	< 4.0	34.0	< 10	< 0.000	< 10.00	< 0.0	.028	< 0.0	J 5.0
S1 FB	31	5/28	< 1.0	7.0	29.0	< 10	.520	J 10.00	< 0.0	.300	< 0.0	J 5.0

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TABLE 4.2-7

Influent and Effluent Radionuclides

Sample Location	Sample Number	Sample Date	Time of Collection	GR-A (PCI/liter)	GR-B (PCI/liter)	RA-228 (PCI/liter)	TOT-RA (PCI/liter)
S1	5	5/02/91	0920	L.T. 4.	5.6 +-2.6	L.T. 1.	L.T. 1.
S1	5	5/02/91	0921	L.T. 4.	5.6 +-2.5	L.T. 1.	L.T. 1.
S1	5	5/02/91	1115	L.T. 4.	L.T. 2.	L.T. 1.	L.T. 1.
S1	16	5/13/91	1112	L.T. 5.	L.T. 4.	L.T. 2.	L.T. 2.
S1	23	5/20/91	0829	L.T. 4.	L.T. 4.	L.T. 0.6	L.T. 0.7
S1	23	5/20/91	0920	L.T. 4.	L.T. 4.	L.T. 1.	L.T. 0.7
S6	5	5/02/91	1018	L.T. 4.	5.7 +-2.6	L.T. 0.9	L.T. 2.
S6	16	5/13/91	1203	L.T. 5.	L.T. 4.	L.T. 2.	L.T. 2.

GR-A = Gross Alpha
 GR-B = Gross Beta
 RA-228 = Radium - 228
 TOT-RA = Total Radium
 PCI = picocuries
 L.T. = less than

TABLE 4.2-8

Influent Physical Parameters and Field Measurements

Field Measurements						Physical Parameters (mg/L)				
Sample Name	Sample Number	Sample Date	Conductivity			Hydrogen Peroxide (mg/l)	Physical Parameters			
			pH (su)	(umhos/cm)	Temperature (Celsius)		TSS	TDS	Alk	Hardness
S1	3	4/30	7.74	950	11.0		3			266
S1	4	5/01	6.46	875	11.5		1			
S1	5	5/02	6.82	875	12.0		1	649	78	
S1	6	5/03	6.26	850	11.0		1			
S1	7	5/05					< 1			251
S1	8	5/05	6.47	850	11.5		< 1			
S1	9	5/06	6.24	825	12.0		< 1			265
S1	10	5/07	6.58	825	12.0		< 1			
S1	11	5/08	6.23	875	11.5		< 1			258
S1	12	5/09	7.79	850	12.0		< 1			
S1	13	5/10	6.21	875	13.1		< 1			
S1	14	5/11	6.09	825	12.2		< 1			
S1	15	5/12	6.09	850	13.0		< 1			
S1	16	5/13	7.75	850	13.9		< 1	626	74	262
S1	17	5/14	6.15	850	14.0		< 1			
S1	18	5/15	6.27	890	12.0		< 1			
S1	19	5/16	6.30	840	13.0		< 1			
S1	20	5/17	6.63	850	13.5		< 1			
S1	21	5/18	5.96	810	13.0		< 1			
S1	22	5/19	6.20	800	12.5		< 1			
S1	23	5/20	6.49	825	12.7		< 1	672	72	270
S1	24	5/21	6.50	825	13.0		< 1			
S1	25	5/22	6.81	825	14.0		< 1			
S1	26	5/23	6.45	800	12.9		< 1			
S1	27	5/24	6.47	825	14.0		< 1			
S1	28	5/25	6.77	825	14.0		< 1			
S1	29	5/26	6.11	800	14.0		< 1			
S1	30	5/27	6.71	800	14.0		< 1			
S1	31	5/28	6.74	800	14.9		< 1	608	71	263
S1	32	5/29	6.68	800	14.0		< 1			
S1	33	5/30	6.91	775	13.0		< 1			
S1 FB	3	4/30					< 1			
S1 FB	4	5/01					< 1			
S1 FB	5	5/02					< 1	3	2	
S1 FB	6	5/03					< 1			
S1 FB	7	5/04					< 1			
S1 FB	8	5/05					< 1			
S1 FB	9	5/06					< 1			
S1 FB	10	5/07					< 1			
S1 FB	11	5/08					< 1			
S1 FB	12	5/09					< 1			
S1 FB	13	5/10					< 1			
S1 FB	15	5/12					< 1			
S1 FB	16	5/13					< 1	4	2	
S1 FB	17	5/14					< 1			
S1 FB	18	5/15					< 1			
S1 FB	19	5/16					< 1			

1. Calculated from reported calcium and magnesium concentrations
and presented in units of mg/l as CaCO₃

J:\projects\1-0703-2\database\slfparam.db Prepared by The Johnson Company

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TABLE 4.2-8 (cont.)

Sample Name	Sample Number	Sample Date	Field Measurements			Physical Parameters (mg/L)				1
			pH (su)	Conductivity (umhos/cm)	Temperature (Celsius)	Hydrogen Peroxide (mg/l)	TSS	TDS	Alk	Hardness
S1 FB	20	5/17					< 1			
S1 FB	21	5/18					< 1			
S1 FB	22	5/19					< 1			
S1 FB	23	5/20					< 1	< 1	2	
S1 FB	26	5/23					< 1			
S1 FB	27	5/24					< 1			
S1 FB	28	5/25					< 1			
S1 FB	29	5/26					< 1			
S1 FB	30	5/27					< 1			
S1 FB	32	5/29					< 1			
S1 FB	31	5/28					< 1	< 1	1	
S1 FB	33	5/30					< 1			

su = Standard units

TSS = Total suspended solids

TDS = Total dissolved solids

Alk = Alkalinity

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1. Calculated from reported calcium and magnesium concentrations and presented in units of mg/l as CaCO₃

4.2.3.4 Effluent Characterization

The effluent quality was characterized by the collection of samples from the outlet pipe from the final collection tank (S6), where the effluent from the final carbon tank discharged. Samples from this location were collected on days indicated and analyzed for compounds shown in Table 4.2-2. Effluent sample (S6) results for some of the groups of compounds listed in Table 4.2-2 have been summarized in the following tables:

Effluent Volatile Organic Compounds - Laboratory Results: Table 4.2-9

Effluent Volatile Organic Compounds - Field Analytical System Results: Table 4.2-10

Effluent Inorganics: Table 4.2-11

Effluent Physical Parameters and Field Measurements: Table 4.2-12

Semi-volatile organics and Pesticides/PCB in the effluent have not been summarized in tables for the text of this report because none of these compounds were detected by the laboratory. The laboratory results indicating the detection limits for these compounds are included in Appendix G.

4.2.3.5 Quality Assurance/Quality Control

Quality Assurance/Quality Control (QA/QC) practices were applied to the following areas of work accomplished during the treatability test:

- Areal well sampling and monitoring
- Treatment system sampling and monitoring
- Treatment system operations
- Treatment system decommissioning
- Laboratory analyses and reporting
- Data review

The specific practices followed for each of these areas of work are described as follows.

Areal Well Sampling and Monitoring

Generally, the field methods specified in the QA/QC Plan, revision of March 15, 1991 were followed during the collection of areal well samples. Samples were collected in accordance with ENSR SOP 7130 and placed in containers and preserved in accordance with the requirements outlined in Table 4-4 of the QA/QC Plan.

TABLE 4.2-9

Effluent Volatile Organic Compounds - Laboratory Results (µg/l)

Sample Name	Sample Number	Sample Date	1,1-dichloro ethane	1,1-dichloro ethene	1,2-dichloro ethene	Tetrachloro ethene	Trichloro ethene	1,1,1-tri chloroethane
S6	3	4/30	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	4	5/01	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	5	5/02	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	6	5/03	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	7	5/04	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	8	5/05	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	9	5/06	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	10	5/07	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	11	5/08	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	12	5/09	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	13	5/10	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	14	5/11	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	15	5/12	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	16	5/13	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	17	5/14	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	18	5/15	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	19	5/16	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	20	5/17	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	21	5/18	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	22	5/19	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	23	5/20	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	24	5/21	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	25	5/22	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	26	5/23	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	27	5/24	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	28	5/25	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	29	5/26	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	30	5/27	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	31	5/28	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	32	5/29	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	33	5/30	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

NOTES: "J" indicates that concentrations below detection limits were observed.

TABLE 4.2-10

Effluent Volatile Organic Compounds
A+RT Field Organics Analyzer System Results (µg/l)

Sample Name	elapDate in May	Vinyl Chloride	1,1-dichloro ethene	t-DCE	1,1-dichloro ethane	c-DCE	Trichloro ethane	1,2-dichloro ethane	Trichloro ethene	Tetrachloro ethene
S6	15.91	0.0	0.00		.04	.03	.20	0.00	.05	.78
S6	17.14	0.0	.06	0.00	.03	.02	.17	0.00	.04	.32
S6	17.67	0.0	.06	0.00	0.00	.07	.24	0.00	.03	.72
S6	18.06	0.0	.06	0.00	.04	0.00	.18	0.00	.03	.24
S6	18.81	0.0	.05	0.00	.03	.02	.17	0.00	.08	1.60
S6	19.04	0.0	.04	0.00	.03	.01	.17	0.00	.05	1.45
S6	19.26	0.0	.04	0.00	.03	.01	.16	0.00	.04	1.39
S6	20.02	0.0	.05	0.00	.03	.02	.16	0.00	.06	1.06
S6	20.06	0.0	.04	0.00	.02	.02	.17	0.00	.05	.75
S6	20.81	0.0	.05	0.00	.09	.05	.29	0.00	.09	.84
S6	21.04	0.0	.03	0.00	.08	.02	.30	0.00	.03	.96
S6	21.26	0.0	.02	0.00	.08	.02	.26	0.00	.03	1.40
S6	21.83	0.0	.05	0.00	.08	.02	0.00	0.00	.04	1.40
S6	22.19	0.0	.06	0.00	.06	.01	.20	0.00	.03	2.00
S6	22.81	0.0	.04	0.00	.07	0.00	.24	0.00	.03	1.08
S6	23.06	0.0	.03	0.00	.08	0.00	.25	0.00	.06	1.00
S6	24.17	0.0	.03	0.00	.07	0.00	.20	0.00	.07	.91
S6	24.97	0.0	.05	.01	.09	.02	.27	0.00	.09	1.20
S6	25.52	0.0	.03	0.00	.07	0.00	.23	0.00	.05	1.60
S6	26.28	0.0	0.00	0.00	.06	0.00	.21	0.00	.06	3.10
S6	27.21	0.0	0.00	0.00	.07	.02	.17	0.00	.05	1.30
S6	27.94	.1	.01	.02	.05	.01	.10	.17	.03	1.50
S6	28.21	0.0	.09	0.00	.13	0.00	.27	0.00	.06	1.90
S6	28.84	0.0	.05	0.00	.05	.02	.11	0.00	.04	1.10
S6	29.11	0.0	.04	0.00	.04	0.00	.12	0.00	.02	1.10
S6	29.66	0.0	0.00	0.00	0.00	0.00	.05	0.00	.05	1.20
S6	29.93	0.0	0.00	0.00	0.00	0.00	.04	0.00	.04	.95
S6	30.19	0.0	0.00	0.00	0.00	0.00	.04	0.00	.04	1.10
S6	30.47	0.0	0.00	.06	0.00	0.00	.10	0.00	0.00	.90

elapDate in May = sample date and time where time is represented by a decimal fraction
(e.g., 17.67 = May 17, 4:05 p.m.)

t-DCE = trans-1,2-dichloroethene

c-DCE = cis-1,2-dichloroethene

TABLE 4.2-11

Effluent Inorganics - Laboratory Results (µg/l)

Sample Name	Sample Number	Sample Date	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium (Total)	Chromium (Hexavalent)	Cobalt
S6	3	4/30	239.	1.00	< 1.0	J 22.0	< 1.0	< 3.0	80300	J10.0		< 6.0
S6	5	5/02	< 195.	< 1.00	< 1.0	J 24.0	< 1.0	< 3.0	84000	J10.0		< 6.0
S6	7	5/04	< 195.	< 3.00	< 1.0	J 16.0	< 1.0	< 3.0	86900	<10.0		< 6.0
S6	9	5/06	< 195.	< 1.00	< 1.0	J 18.0	< 1.0	< 3.0	86800	J10.0		< 6.0
S6	11	5/08	< 195.	< 1.00	< 1.0	J 19.0	< 1.0	< 3.0	88900	J10.0		< 6.0
S6	16	5/13	< 195.	< 1.00	< 1.0	J 19.0	< 1.0	< 3.0	93800	J10.0	R 0	< 6.0
S6	23	5/20	< 195.	< 1.00	< 1.0	J 18.0	< 1.0	< 3.0	90500	<10.0	< 0	< 6.0
S6	31	5/28	< 195.	< 1.00	< 1.0	J 16.0	< 1.0	< 3.0	89200	<10.0	< 0	< 6.0
S6 FB	5	5/02	< 195.	< 1.00	< 1.0	< 13.0	< 1.0	< 3.0	< 448	J10.0		< 6.0

NOTES: "J" indicates that concentrations below detection limits were observed.
 "R" indicates that the data was rejected by the data validator.

TABLE 4.2-11 (cont.)

Sample Name	Sample Number	Sample Date	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium
S6	3	4/30	8.0	< 98.0	J 1.0	11200	10.0	<0.00	< 9.0	3310	J 1.00	J 8.0	128000
S6	5	5/02	<14.0	<149.0	< 1.0	10800	13.0	<0.00	< 9.0	3210	J 1.00	J 14.0	105000
S6	7	5/04	< 5.0	< 98.0	3.0	10400	6.0	<0.00	< 9.0	2250	< 1.00	J 8.0	99800
S6	9	5/06	< 5.0	< 98.0	2.0	10700	3.0	<0.00	< 9.0	2310	< 1.00	J 8.0	93900
S6	11	5/08	< 5.0	< 98.0	< 1.0	10500	5.0	<0.00	< 9.0	2540	< 1.00	J 8.0	89700
S6	16	5/13	< 8.0	<216.0	< 2.0	10800	3.0	<0.00	< 9.0	2930	< 1.00	J 10.0	83100
S6	23	5/20	6.0	< 98.0	J 1.0	10000	< 2.0	<0.00	< 9.0	2960	< 1.00	< 8.0	79700
S6	31	5/28	< 5.0	< 98.0	< 2.0	10400	< 3.0	<0.00	< 9.0	2550	J 1.00	J 9.0	75800
S6 FB	5	5/02	5.0	< 98.0	< 1.0	< 509	< 2.0	<0.00	< 9.0	< 760	< 1.00	J 8.2	396

TABLE 4.2-11 (cont.)

Sample Name	Sample Number	Sample Date	Thallium	Vanadium	Zinc	Cyanide	Total Phosphorous	Chloride	Fluoride	NO2-NO3	Dissolved Silica	Sulfate
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
S6	3	4/30	< 1.0	< 4.0	< 57.0							
S6	5	5/02	J 1.0	< 4.0	116.0							
S6	7	5/04	J 1.0	< 4.0	J118.0							
S6	9	5/06	J 1.0	< 4.0	J121.0							
S6	11	5/08	J 1.0	< 4.0	149.0							
S6	16	5/13	J 1.0	< 4.0	<139.0	< 10	< 0.000	259.00	< 0.0	3.100	<11.3	J32.8
S6	23	5/20	J 1.0	5.0	<120.0	< 10	< 0.000	249.00	< 0.0	J 3.900	11.0	J31.3
S6	31	5/28	J 1.0	< 4.0	<113.0	< 10	< 0.000	249.00	< 0.0	3.300	11.0	J34.2
S6 FB	5	5/02	< 1.0	< 4.0	21.0							

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TABLE 4.2-12

Effluent Physical Parameters and Field Measurements

Sample Location	Sample Number	Sample Date	Field Measurements			Hydrogen Peroxide (mg/l)	Physical Parameters				1
			pH (su)	Conductivity (umhos/cm)	Temperature Celsius		TSS	TDS	Alk	Hardness	
S6	3	4/30	9.02	975	15.0	0				247	
S6	4	5/01	6.19	950	14.8	0					
S6	5	5/02	7.44	925	15.0						
S6	6	5/03	6.99	925	14.5						
S6	7	5/04								260	
S6	8	5/05	7.02	850	11.8						
S6	9	5/06	7.26	800	12.0					261	
S6	10	5/07	7.07	900	15.0						
S6	11	5/08	5.94	900	15.0						
S6	12	5/09	7.00	900	15.0						
S6	13	5/10	6.68	900	15.1						
S6	14	5/11	6.61	900	15.0						
S6	15	5/12	6.55	900	15.0						
S6	16	5/13	7.06	901	17.0		< 1	678	72	279	
S6	17	5/14	6.71	900	16.1						
S6	18	5/15	6.53	890	15.5						
S6	19	5/16	6.71	890	16.0						
S6	20	5/17	6.75	899	16.5						
S6	21	5/18	6.69	890	15.0						
S6	22	5/19	6.79	850	14.9						
S6	23	5/20	6.66	825	13.0		< 1	718	71	267	
S6	24	5/21	6.99	890	16.0						
S6	25	5/22	7.10	890	16.9						
S6	26	5/23	6.46	875	17.0						
S6	27	5/24	6.86	890	17.1						
S6	28	5/25	6.94	875	16.0						
S6	29	5/26	6.55	850	16.0						
S6	30	5/27	6.85	850	17.0						
S6	31	5/28	6.78	850	17.0		< 1	682	69	266	
S6	32	5/29	6.97	850	16.0						
S6	33	5/30	7.05	825	16.1						

su = Standard units

TSS = Total suspended solids

TDS = Total dissolved solids

Alk = Alkalinity

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1. Calculated from reported calcium and magnesium concentrations and presented in units of mg/l and CaCO₃

For each sample delivery group, a field blank, a co-located sample and a field duplicate sample were collected. Trip blanks were included by the laboratory in each sample delivery group.

All of the ground-water samples were labeled appropriately and packed and shipped to the laboratory in accordance with ENSR SOP 7510: Packaging and Shipment of Samples. The coolers were shipped via courier on a same-day basis for the first round of sampling and via Federal Express for sampling rounds two and three.

Periodically, duplicate sample material was made available to the EPA Contractor for purposes of Duplicate sample collection and subsequent analysis in an EPA laboratory.

Separate aliquotes were collected at certain predetermined sample locations and analyzed for field parameters with a Hydrolab Water Quality Monitor for dissolved oxygen, temperature, pH, redox potential, and specific conductivity in accordance to ENSR SOP 7320: Calibration and Operation of the Hydrolab Water Quality Monitor.

Some quality assurance deficiencies were experienced in the areal well sampling. These deficiencies are briefly described below:

- Samples, duplicates, matrix spikes and matrix spike duplicates were collected a day apart or at different times on several occasions.
- Chain-of-Custody forms were not signed or dated a little over 10% of the time.
- The transfer sections of the Chain-of-Custody forms were not completed about one-third of the time.
- Strike-outs on the Chain-of-Custody forms were not always initialed or dated.
- Samples collected on different days were included on the Chain-of-Custody forms with only one data indicated.

Although these deficiencies resulted in a reduction of the level of confidence in some of the data, the preponderance of valid data with a high level of confidence that resulted from the sampling program implemented during this investigation presented an adequate representation of the ground-water quality in the Northeast Quadrant.

Treatment System Sampling and Monitoring Sampling

The water pumped from UC22 was treated by the treatment processes described in Section 4.2.1.3. Samples were collected at the influent of the system, the influent to each unit treatment process and side trains, and of the effluent. Samples were collected in the appropriate

containers with preservatives as described in Table 4-4 of the QA/QC Plan, then placed in coolers immediately after collection and shipped to the laboratory with a Chain-of-Custody form. As with the areal well samples collected, trip blanks, co-located samples and field blanks were prepared for each sample delivery group. Samples and sampling conditions were recorded on daily sample collection logs which are included in Appendix I.

Periodically, duplicate samples were collected from the treatment system by the EPA Contractor for analysis in the EPA laboratory.

Several quality assurance deficiencies have been identified in the treatment system sampling. These deficiencies are briefly described below:

- Chain-of-Custody forms were not always signed or dated.
- Sample coolers were often not packed with sufficient ice, resulting in the samples arriving at the laboratory above the 4°C holding temperature.
- The transfer section of the Chain-of-Custody forms were not completed about one-third of the time.

Although these deficiencies resulted in a reduction of the level of confidence in some of the data, the preponderance of valid data with a high level of confidence that resulted from the sampling program implemented during this investigation allowed for an adequate demonstration of the treatment performance of the unit processes, and a high level of confidence that the discharge limits were easily met during the entire treatability test.

Treatment System Operations

The operating conditions of the pumping and treatment systems was monitored on an on-going basis, and any modifications to the system, or non-routine operational events were recorded on daily log sheets (included in Appendix H). Daily inspections of the system were made as described in Section 4.2.2.2 of this report.

Field measurements of pH, temperature and conductivity were made at points within the treatment system and recorded on the daily sampling logs (Appendix H).

The measurements of drawdown and flowrate through the treatment system, were continuously recorded in the data logger during this test. These data were retrieved via modem on a daily basis to ensure that the ground-water extraction system was operating properly.

Treatment System Decommissioning

Upon decommissioning of the treatment system, samples of the residual solid materials collected during well development and well purging and during backwash of the large carbon tank were collected to determine the best means of disposal. The material collected during well development and purging was contained in 55-gallon drums stored outside of the treatment room. Material in these drums was composited for analysis of metals, radionuclides, and VOC. Samples of the backwash solids were also collected for analysis of metals, radionuclides, and VOC. Since these samples were meant to be used for waste evaluation and not system evaluation, no QA/QC samples or duplicate samples were collected. All samples of the residual solid materials were shipped in coolers cooled to 4°C with a Chain-of-Custody form.

Laboratory Analyses and Reporting

The laboratory analytical work, and subsequent reporting of results underwent a comprehensive audit process and QA/AC review before, during and after the treatability test by an independent company; Trillium, Inc. The laboratory prepared complete data packages for review by Trillium, for the purposes of validating the data. This information, and reports regarding the on-going audits and reviews are available in Appendix K of this document.

4.2.4 Treatment System Performance

4.2.4.1 Compliance with Discharge Limits

The effluent monitoring results indicate that the effluent from the UniFirst treatment system met the established discharge limits at all times during the 30-day treatability test. The discharge limits were based on the EPA Fresh Water Acute Criteria for Aquatic Life, and were presented for all compounds being monitored in Tables 2-6 through 2-10 of the Revised Draft Work Plan for the Remedial Design, Hydraulic Characterization Pilot Treatment Test and Final Design, Northeast Quadrant of the Wells G & H Site, Woburn, Massachusetts, Revision of March 15, 1991.

The influent data confirm the previously assumed quality of the pumped ground water and that the treatment processes selected for testing during the treatability study were satisfactory for achieving all of the discharge limits set forth in the Work Plan. Moreover, the primary contaminants of concern at this site: the chlorinated hydrocarbons identified in the ROD, were reduced to virtually nondetectable concentrations prior to discharge. The laboratory detection limit for these compounds was .5 micrograms per liter. The A+RT Field Organics Analyzer System also did not detect any of these compounds above .5 micrograms per liter, with the

exception of tetrachloroethene, which was detected at concentrations ranging from 0.24 to 3.1 micrograms per liter.

The inorganic data presented in Table 4.2-11 shows that no discharge limits were exceeded during the treatability test. Moreover, many of those inorganics with applicable discharge limits were not detected above the laboratory quantitation limits for the duration of the test.

Table 4.2-7 indicates that most of the radionuclides measured were not detectable with the exception of gross beta, which was detected in the influent and effluent on one day (May 2, 1991) of sampling. The measured concentrations of gross beta for both influent and effluent samples were slightly above the laboratory quantitation limits. The measured concentrations of influent and effluent were essentially equal, indicating that no radioactive constituents accumulated in the treatment system (as filtered suspended solids or adsorbed to the carbon).

4.2.4.2 Individual Treatment Process Performance

Multi-Media Filter

The multi-media filter was intended to remove any suspended solids that might be present in the pumped ground water for the purpose of ensuring that the U.V. system maintained a high level of efficiency, and to prevent the carbon filter from becoming clogged with incoming solids. The laboratory analyses of influent water (S1) indicated that total suspended solids were undetected in daily samples except days 1, 2, 3, and 4, when total suspended solids were measured at 3 mg/L on day 1, and 1 mg/L on days 2, 3, and 4. The lack of suspended solids was confirmed by the visual observation of the daily samples, which did not exhibit any perceptible turbidity. As a result of the clarity of the in-coming water, the use of the multi-media filter was not necessary, but provided some level of safety, in the event suspended solids had been observed. Significant suspended solids were observed during the four hours of initial pumping done on April 11, 1991, for trouble shooting and treatment system performance confirmation. Although samples were not collected and analyzed for total suspended solids during this period of pumping, the water was noticeably turbid. It is not possible to quantify how efficient the filter was in the removal of these suspended solids, however, the pressure differential across the filter increased dramatically during the four hours of pumping from 10 psi to 32 psi by the end of the pumping. The filter was backwashed at the end of the pumping period into the backwash tank, and the backwash water was extremely turbid for the first five minutes of backwashing, indicating that a significant amount of solids were removed during the pumping. The measured concentration of suspended solids of 3 mg/L by the time the day 1 sample was collected on April 30, and the decreasing

concentrations after that, indicates that the source of the solids during the first four hours of pumping was probably residual sediment in the well that had accumulated during the two years that the well was stagnate, and sediment that may have been introduced to the system during the equipping of the well for this treatability test.

Ultraviolet/Chemical Oxidation System

The ultraviolet/chemical oxidation (U.V.) treatment system was designed to treat volatile organic compounds to concentrations similar to the target goals identified in the ROD. The treatment provided during the course of the treatability test involved the injection of hydrogen peroxide at a dose rate of 60 mg/L and exposure of the chemically treated water to four-15 KW ultraviolet light bulbs in series in a chamber providing a total contact time of 1.6 minutes. Tables 4.2-13 and 4.2-14 present the data for VOC in the influent to the U.V. system (S4) from the laboratory and the A+RT Field Organics Analyzer System, respectively. The influent samples sent to the laboratory had to be diluted significantly due to the relatively high PCE concentrations, and as a result, the detection limits for the other compounds increased to levels above the actual concentrations in the samples. The A+RT Field Organics Analyzer System analyzed samples for the last 15 days of the test, and reported concentrations down to single digit numbers. This data allows us to evaluate the actual removal efficiency for all of the compounds measured. If Table 4.2-14 (the influent to the U.V. system) is compared to Table 4.2-5 (the raw ground water entering the multimedia-media filter), it can be seen that the concentrations of all of the VOC have reduced significantly by the time the main flow entered the UV system. The organic compounds were reduced ahead of the U.V. system by the following three mechanisms:

- (1) the carbon side train removed organics from approximately 12 gpm of the raw ground water and reinjected this flow back into the main line ahead of the U.V. system,
- (2) the side train for the experimental dehalogenation medium (University of Waterloo) removed organics from approximately 1 gpm of the raw ground water and reinjected this flow back into the main line ahead of the U.V. system, and
- (3) one of the media in the multi-media filter was activated carbon, which removed some of the organics in the raw ground water, particularly during the first days of the test before this carbon became saturated.

These combined effects caused an approximate 40 percent reduction in the organic concentrations from the raw ground water to the influent to the U.V. system. This reduction did not detract from the ability to obtain good treatability data for the purposes of final design.

TABLE 4.2-13

**Volatile Organic Compounds in the Influent to UV/Chem. Ox. System
Laboratory Results (µg/l)**

Sample Name	Sample Number	Sample Date	1,1-dichloro ethane	1,1-dichloro ethene	1,2-dichloro ethene	Tetrachloro ethene	Trichloro ethene	1,1,1-tri chloroethane
S4	1	4/30	<5.0	<5.0	<5.0	170.0	J3.0	<5.0
S4	2	5/01	<5.0	<5.0	<5.0	90.0	J3.0	<5.0
S4	3	5/02	<25.0	<25.0	<25.0	280.0	<25.0	<25.0
S4	4	5/03	<25.0	<25.0	<25.0	440.0	<25.0	<25.0
S4	5	5/04	<25.0	<25.0	<25.0	590.0	<25.0	<25.0
S4	6	5/05	<25.0	<25.0	<25.0	850.0	<25.0	<25.0
S4	7	5/06	<25.0	<25.0	J10.0	870.0	J18.0	J10.0
S4	8	5/07	<25.0	<25.0	J6.0	1000.0	J23.0	<25.0
S4	9	5/08	<25.0	<25.0	<25.0	1100.0	J25.0	J15.0
S4	10	5/09	<5.0	<5.0	<5.0	130.0	<5.0	<5.0
S4	11	5/10	<50.0	<50.0	<50.0	1400.0	J29.0	<50.0
S4	12	5/11	<50.0	<50.0	<50.0	1400.0	<50.0	<50.0
S4	13	5/12	<50.0	<50.0	<50.0	1500.0	<50.0	<50.0
S4	14	5/13	<50.0	<50.0	<50.0	1500.0	<50.0	<50.0
S4	15	5/14	<50.0	<50.0	<50.0	1400.0	<50.0	<50.0
S4	16	5/15	<50.0	<50.0	<50.0	1600.0	<50.0	<50.0
S4	17	5/16	<50.0	<50.0	<50.0	2000.0	<50.0	<50.0
S4	18	5/17	<50.0	<50.0	<50.0	1600.0	<50.0	<50.0
S4	19	5/18	<50.0	<50.0	<50.0	1700.0	J45.0	<50.0
S4	20	5/19	<50.0	<50.0	<50.0	2000.0	<50.0	<50.0
S4	21	5/20	<50.0	<50.0	<50.0	1900.0	73.0	J44.0
S4	22	5/21	<50.0	<50.0	<50.0	2000.0	59.0	J36.0
S4	23	5/22	<50.0	<50.0	<50.0	2000.0	58.0	<50.0
S4	24	5/23	<50.0	<50.0	<50.0	1700.0	J50.0	J30.0
S4	25	5/24	<50.0	<50.0	<50.0	1700.0	52.0	J29.0
S4	26	5/25	<50.0	<50.0	<50.0	1400.0	J42.0	J25.0
S4	27	5/26	<50.0	<50.0	<50.0	1800.0	56.0	J31.0
S4	28	5/27	<50.0	<50.0	J14.0	1100.0	33.0	J18.0
S4	29	5/28	<50.0	<50.0	<50.0	2300.0	77.0	J41.0
S4	30	5/29	<50.0	<50.0	J38.0	2400.0	80.0	J44.0
S4	31	5/30	<50.0	<50.0	<50.0	2200.0	75.0	<50.0

NOTES: "J" indicates that concentrations below detection limits were observed.

TABLE 4.2-14

Volatile Organic Compounds in the Influent to UV/Chem. Ox. System
A+RT Field Organics Analyzer System (µg/L)

Sample Name	Sample Date in May	Vinyl Chloride	1,1-dichloro ethene	T-DCE	1,1-dichloro ethane	C-DCE	Trichloro ethane	Trichloro ethene	Tetrachloro ethene
S4	17.47	0.0	3.80	0.00	2.70	10.30	18.30	35.20	1463
S4	18.15	0.0	6.80	0.00	3.10	12.80	18.80	40.20	1661
S4	18.64	0.0	9.10	1.70	3.80	15.70	39.20	63.30	2405
S4	18.64	0.0	11.70	2.40	4.80	21.00	51.70	82.60	2712
S4	18.86	0.0	8.60	1.20	2.90	13.00	28.80	50.10	2097
S4	19.08	0.0	7.60	0.00	3.00	12.80	29.00	48.70	2164
S4	19.30	0.0	6.30	0.00	3.10	13.20	26.80	47.90	2120
S4	20.11	0.0	8.10	0.00	2.80	14.30	28.80	52.70	2211
S4	20.32	0.0	4.97	0.00	2.57	12.16	26.36	49.30	2123
S4	20.32	0.0	9.74	0.00	2.54	12.98	20.02	48.15	1986
S4	20.85	0.0	6.30	0.00	3.00	14.40	25.10	50.90	2131
S4	21.09	0.0	4.80	0.00	2.90	12.70	23.90	47.00	2031
S4	21.31	0.0	4.00	0.00	2.70	12.50	23.50	47.00	2058
S4	22.10	0.0	10.20	0.00	3.00	13.60	27.00	53.50	2316
S4	22.27	0.0	5.30	0.00	3.00	12.90	25.80	50.90	2289
S4	22.27	0.0	7.10	0.00	3.30	13.40	25.00	50.10	2249
S4	23.33	0.0	4.30	0.00	2.60	13.90	28.80	60.40	2308
S4	23.74	0.0	4.90	1.70	3.50	15.50	30.50	63.00	2384
S4	23.74	0.0	5.30	1.70	3.20	14.70	32.30	64.20	2278
S4	24.69	0.0	5.20	1.50	3.40	17.70	36.60	72.00	2758
S4	24.69	0.0	6.10	1.10	3.80	16.30	36.30	70.00	2806
S4	25.43	0.0	5.20	0.00	3.30	15.20	33.90	69.60	3052
S4	25.97	0.0	7.60	0.00	2.80	14.90	28.10	65.20	2915
S4	27.03	0.0	6.60	.09	6.20	19.10	27.10	65.30	2607
S4	27.85	0.0	6.70	0.00	2.10	14.90	27.10	64.20	2559
S4	28.12	10.5	23.50	0.00	9.00	26.30	37.30	101.00	3687
S4	28.75	0.0	10.00	.80	2.10	14.50	23.00	62.20	2292
S4	29.02	0.0	9.30	0.00	2.40	13.10	22.90	55.80	2191
S4	29.28	0.0	6.20	0.00	2.00	12.60	20.40	54.30	2102
S4	29.57	0.0	5.00	0.00	2.50	14.80	25.40	64.90	2716
S4	29.70	0.0	3.50	0.00	2.10	12.80	22.80	60.10	2222
S4	29.97	0.0	5.10	0.00	2.00	12.20	21.50	58.60	2193
S4	30.24	0.0	4.00	0.00	1.60	10.90	20.10	53.60	2118

Sample Date in May = sample date and time where time is represented by a decimal fraction
(e.g., 17.67 = May 17, 4:05 P.M.)

t-DCE = trans-1,2-dichloroethene

c-DCE = cis-1,2-dichloroethene

The concentrations of VOC in the effluent from the U.V. system are shown in Tables 4.2-15 (laboratory data) and 4.2-16 (A+RT Field Organics Analyzer System). The data indicates that the U.V. system (during normal operation) effectively removed all of the VOCs, with the exception of 1,1,1-trichloroethane, down to concentrations less than 5 µg/L, and in many cases, less than 0.5 µg/L. Trichloroethane was not effectively treated through the U.V. system, however this was expected because the U.V. system was not designed to remove trichloroethane. Trichloroethane is a relatively difficult compound to remove with U.V. technology, and would have required significantly higher chemical dosages and U.V. contact time, decreasing this technology's economic viability. The decision to not specifically treat this compound with the U.V. system was made primarily because the influent concentrations for trichloroethane were expected to be significantly lower than either the target goal for the aquifer as well as the discharge limit for this test or the final treatment system. The lowest of these numbers is the target goal for the aquifer (200 µg/L), and the mean influent concentration of trichloroethane during the treatability test was 34 µg/L. In addition, the final polishing step of carbon in the treatability test was expected to remove the trichloroethane from the U.V. system effluent.

One laboratory sample result and two field analytical system results for the UV system effluent indicated noticeable jumps in VOC concentrations. These sample dates were May 8 (Table 4.2-15), and May 18 and 22 (Table 4.2-16). These sample dates were coincident with operational events where the chemical feed system to the U.V. unit was not functioning properly, and as a result, oxidation of the organic compounds was accomplished by exposure to ultraviolet light alone, without hydrogen peroxide addition, reducing the efficiency of the oxidation process.

Field measurements taken of the effluent from the U.V. unit included pH, conductivity, temperature and an occasional measurement of residual hydrogen peroxide. The results of these measurements are summarized in Table 4.2-17. Also, mean values of all measurements taken of the influent and effluent are summarized below.

	<u>Mean Value</u>	
	<u>Influent (S1)</u>	<u>Effluent From U.V (S5)</u>
pH (S.U.)	6.56	6.64
Conductivity (µmhos/cm)	837	885
Temperature (°C)	12.8	15.7

pH did not change significantly from the influent to the effluent given the error inherent in a field measurement. Conductivity increased only slightly (about 6%) perhaps due to the addition of

TABLE 4.2-15

**Volatile Organic Compounds in the Effluent for UV/Chem. Ox. System
Laboratory Results (µg/l)**

Sample Name	Sample Number	Sample Date	1,1-dichloro ethane	1,1-dichloro ethene	1,2-dichloro ethene	Tetrachloro ethene	Trichloro ethene	1,1,1-tri chloroethane
S5	1	4/30	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S5	2	5/01	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S5	3	5/02	<1.0	<1.0	<1.0	<1.0	<1.0	J3.0
S5	4	5/03	<1.0	<1.0	<1.0	<1.0	<1.0	J4.9
S5	5	5/07	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S5	6	5/08	J2.3	R	<1.0	J62.0	J9.3	J25.0
S5	7	5/09	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S5	8	5/10	J1.2	J.9	<1.0	<1.0	<1.0	J13.6
S5	9	5/11	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S5	10	5/12	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S5	11	5/13	J2.6	J1.0	<1.0	<1.0	<1.0	J25.0
S5	12	5/14	J2.2	J.9	<1.0	<1.0	<1.0	J19.0
S5	13	5/15	2.0	<1.0	<1.0	<1.0	<1.0	25.0
S5	14	5/16	2.2	1.2	<1.0	<1.0	<1.0	27.0
S5	15	5/17	2.7	1.6	<1.0	<1.0	<1.0	J28.0
S5	16	5/18	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S5	17	5/19	3.2	1.7	<1.0	<1.0	<1.0	30.0
S5	18	5/20	3.8	1.4	<1.0	2.5	<1.0	J32.0
S5	19	5/21	J4.6	J2.0	<1.0	<1.0	<1.0	J29.0
S5	20	5/22	4.4	1.9	<1.0	<1.0	<1.0	J33.0
S5	21	5/23	1.0	1.8	<1.0	<1.0	<1.0	J33.0
S5	22	5/24	1.7	1.5	<1.0	<1.0	<1.0	31.0
S5	23	5/25	2.0	1.7	<1.0	<1.0	<1.0	29.0
S5	24	5/26	2.1	1.7	<1.0	<1.0	<1.0	28.8
S5	25	5/27	2.4	1.8	<1.0	<1.0	<1.0	30.0
S5	26	5/23	2.1	1.5	<1.0	<1.0	<1.0	28.0
S5	27	5/29	2.4	1.6	<1.0	<1.0	<1.0	28.0
S5	28	5/30	2.6	1.5	<1.0	<1.0	<1.0	26.0

NOTES: "J" indicates that concentrations below detection limits were observed.
"R" indicates that the data was rejected by the data validator.

TABLE 4.2-16

Volatile Organic Compounds in the Effluent from UV/Chem. Ox. System
A+RT Field Organics Analyzer System Results (µg/l)

Sample Name	Sample Date in May	Vinyl Chloride	1,1-dichloro ethene	t-DCE	1,1-dichloro ethane	c-DCE	Trichloro ethane	Trichloro ethene	Tetrachloro ethene
S5	17.38	0.00	2.10	0.00	3.30	0.00	27.00	.08	2.60
S5	18.10	0.00	32.00	.30	6.30	6.50	34.40	12.40	84.60
S5	18.99	0.00	1.70	0.00	3.50	0.00	34.10	.10	2.70
S5	19.21	0.00	1.40	0.00	3.60	0.00	34.70	.05	2.50
S5	19.35	0.00	1.70	0.00	3.80	0.00	36.40	.04	2.00
S5	19.96	0.00	1.10	0.00	3.70	.03	37.50	.09	2.60
S5	21.00	0.00	1.80	0.00	4.60	0.00	34.10	.04	1.20
S5	21.22	0.00	1.50	0.00	5.30	.03	36.10	.10	2.10
S5	22.14	.24	5.20	.20	6.80	24.10	39.00	75.00	250.00
S5	22.52	0.00	1.20	0.00	5.00	.02	36.10	.07	.90
S5	23.27	0.00	5.00	0.00	2.10	0.00	27.50	.08	2.10
S5	24.13	0.00	.70	0.00	2.10	.03	37.70	.11	1.80
S5	25.47	0.00	.80	0.00	2.50	0.00	39.40	.08	3.00
S5	27.16	0.00	1.20	0.00	2.50	.01	37.60	.07	2.10
S5	27.89	0.00	.90	0.00	2.60	0.00	33.20	.06	2.10
S5	28.16	0.00	4.10	0.00	4.50	0.00	52.60	.08	3.10
S5	28.80	0.00	1.10	0.00	2.60	0.00	30.70	.07	1.60
S5	29.06	0.00	1.20	0.00	2.50	0.00	30.10	.05	1.80
S5	29.33	0.00	.87	0.00	2.50	0.00	29.50	.04	1.55
S5	29.62	0.00	.53	0.00	3.50	0.00	34.10	.04	2.00
S5	29.88	0.00	.66	0.00	2.80	0.00	29.50	.04	1.40
S5	30.15	0.00	.53	0.00	2.50	0.00	29.30	.04	1.40
S5	30.42	0.00	.54	0.00	3.10	0.00	31.00	.03	1.40

Sample Date in May = sample date and time where time is represented by a decimal fraction
(e.g., 17.67 = May 17, 4:05 P.M.)

t-DCE = trans-1,2-dichloroethene

c-DCE = cis-1,2-dichloroethene

TABLE 4.2-17

Field Measurements
Effluent from UV/Chemical Oxidation

Sample Location	Sample Number	Sample Date	pH (su)	Conductivity (umhos/cm)	Temperature (Celsius)	Hydrogen Peroxide (mg/l)
S5	2	5/01	6.46	950	14.5	5
S5	3	5/02	7.33	925	15.0	
S5	4	5/03	6.60	925	14.5	
S5	5	5/07	6.82	900	14.9	
S5	6	5/08	6.38	900	15.0	
S5	7	5/09	7.27	900	15.0	
S5	8	5/10	6.39	900	15.0	
S5	9	5/11	6.25	900	14.9	
S5	10	5/12	6.25	900	15.0	
S5	11	5/13	7.08	901	16.5	
S5	12	5/14	6.45	900	16.0	
S5	13	5/15	6.27	890	15.0	
S5	14	5/16	6.53	890	15.5	
S5	15	5/17	6.73	899	16.0	
S5	16	5/18	6.39	890	15.0	
S5	17	5/19	6.55	850	14.9	
S5	18	5/20				8
S5	19	5/21	6.69	890	16.0	5
S5	20	5/22	6.88	890	16.0	
S5	21	5/23	6.73	850	16.0	
S5	22	5/24	6.44	850	17.0	
S5	23	5/25	6.75	890	17.0	
S5	24	5/26	6.35	850	16.0	
S5	25	5/27	6.72	850	17.0	
S5	26	5/28	6.66	850	17.0	
S5	27	5/29	6.81	850	15.9	8
S5	28	5/30	6.96	825	16.9	

iron to the system from the dehalogenation media. Temperature increased about 3°C, most likely the result of heat transfer from the ultra-violet bulbs.

In addition to operating the U.V. system during the entire treatability test, an optimization study was performed at the site on May 21, 1991. During this study, the chemical dosage and the contact time were varied, and samples collected from the effluent, to optimize the chemical and power requirements for the system, while continuing to provide adequate treatment. The results of this study are presented in a separate report prepared by Peroxidation Systems, Inc. which is included in Appendix L. The optimization study provided information which has enabled us to extrapolate the findings to different contaminant concentrations and different flow rates as needed in the final design of the treatment system.

Granular Activated Carbon

The purpose of the granular activated carbon (G.A.C.) tank as a final treatment step was to 1) provide redundant treatment in the event that the U.V. system didn't perform as expected, 2) provide treatment in the event that the U.V. system needed to be shut down for servicing, and 3) treat any residual organic concentrations in the U.V. effluent prior to discharge. The UV unit performed well under normal operating conditions during the 30-day test, so item 1 above was not required. However, the carbon tank did treat the effluent for the conditions listed in items 2 and 3. As seen in Table 4.2-3, there were several operational events when the UV unit was not fully functional, and the U.V. effluent during these events, although still easily meeting the discharge limits, was of somewhat lower quality than during other times. In addition, and as discussed previously, the U.V. unit was not designed to remove 1,1,1-trichloroethane effectively. As a result, the effluent from the U.V. unit contained a mean concentration of 1,1,1-trichloroethane of 29 µg/l (calculated from the laboratory data for days 15-30).

As indicated in Table 4.2-9 (laboratory data), there were no detectable concentrations of any of the VOC, including 1,1,1-trichloroethane in the final effluent from the treatment system. The nearly complete removal of VOC by the final carbon polishing step is also confirmed by the data from the A+RT Field Organics Analyzer System (Table 4-10).

A side carbon train was operated during the treatability test to obtain additional data on carbon use, in the event that carbon was selected as the primary treatment process. Raw ground water, after it passed through the multi-media filter, was allowed to pass through the carbon drum at a continuous flow rate of 12 gpm during the entire treatability test. The primary information desired from this test was contaminant breakthrough information. Samples were collected at points within the carbon drum in an attempt to define the mass transfer zone within the carbon drum during the test in order to get breakthrough information. The results from this test did not

provide the information necessary to fully evaluate carbon use requirements when using carbon as the primary treatment process. The primary reasons for this are as follows:

- (1) The detection limits from the laboratory analyses of the influent were too high to allow for a determination of the total mass of the contaminants entering the carbon drum and occupying adsorption sites. The A+ RT Field Organics Analyzer System, which did have the capability to detect extremely low concentrations, was not on line until the final 15 days of the 30 day test, by which time break-through had already occurred at our point of sampling.
- (2) The analytical results of samples collected within the carbon drum were not received quickly, and as a result, when the A+ RT Field Organics Analyzer System was put on line on day 15, we were unaware that breakthrough at the S3A port had already occurred, yet samples continued to be collected at that point.

The treatability test did provide sufficient data on the influent quality (via the A+ RT Field Organics Analyzer System) to allow for a calculation of carbon use requirements, using theoretical and empirical models, for the purposes of economic projections of carbon use as the primary treatment process.

Experimental Dehalogenation Medium

UniFirst and Grace in cooperation with the Centre for Groundwater Research at the University of Waterloo, Ontario, Canada took advantage of the pilot test to investigate the performance of a dehalogenation medium that is under experimentation and development at the Centre for Groundwater Research. The pilot test provided an excellent experimental basis for examining the ability of the medium to treat a genuine contaminated ground-water stream for 30 days at a Superfund site. The purpose of the experiment was to determine whether the dehalogenation medium would work on the contaminant load in the ground-water pumped from UC22 during the pilot test, and, if so, whether the medium would provide a cost-effective alternative-treatment for long-term implementation at UC22.

This medium was selected because preliminary investigations have shown that contact between metal surfaces, such as iron, and water that contains dissolved fractions of chlorinated hydrocarbon solvents can result in substantial rates of degradation of halogenated organic compounds through a dehalogenation process. Experiments to date have indicated rates of degradation that are often several factors of 10 greater than those typically reported for other forms of abiotic and biotic degradation. In addition to laboratory bench-scale tests, this medium

is currently being used in a long-term experiment at the Borden aquifer in Ontario. To date, this experiment has developed very positive results.

The installation and performance of the experimental unit used during the pilot test is described in Appendix M. In summary, the test system consisted of two canisters through which an approximately 1 gallon-per-minute side-stream from the multi-media filter was pumped. Figure 2-5 from the Work Plan (EPC, 1991) illustrates the layout of the canisters in the treatment train. The control canister contained a packed bed of mixed granular activated carbon and silica sand. The reactive canister contained a packed bed of mixed granulated activated carbon, silica sand and iron filings. These canisters were operated for the duration of the entire pilot test through the month of May, 1991.

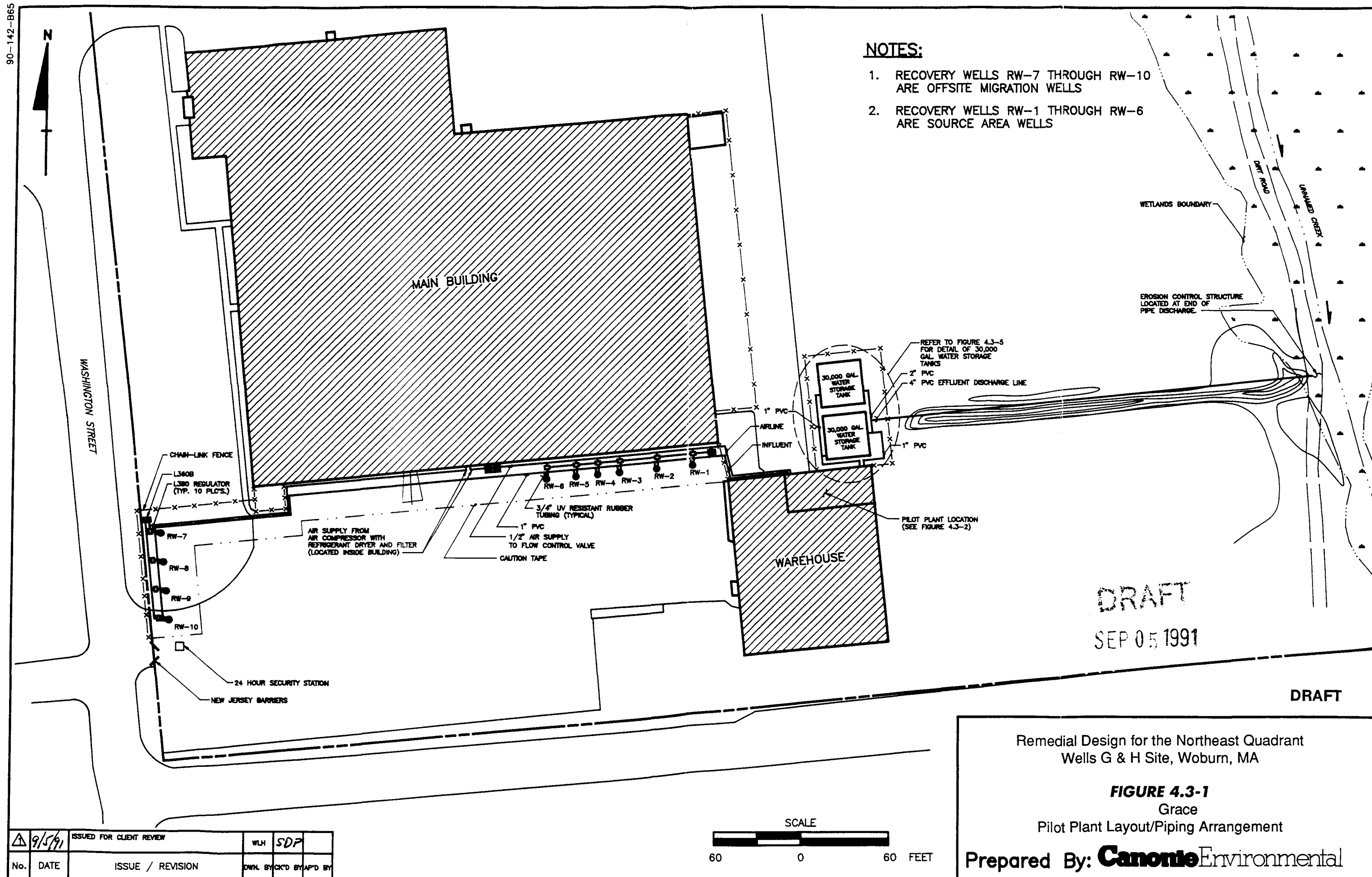
The results of the experiment were not positive. The results indicated that there was a rise in the contaminant-compound concentrations towards the effluent end of the reactive canister. This result is attributed, most likely to, a problem with bypassing or short-circuiting through the reactive medium. This problem, most likely, resulted from incomplete mixing of the reactive medium. This hypothesized mechanism of failure could not be substantiated in the duration of the test.

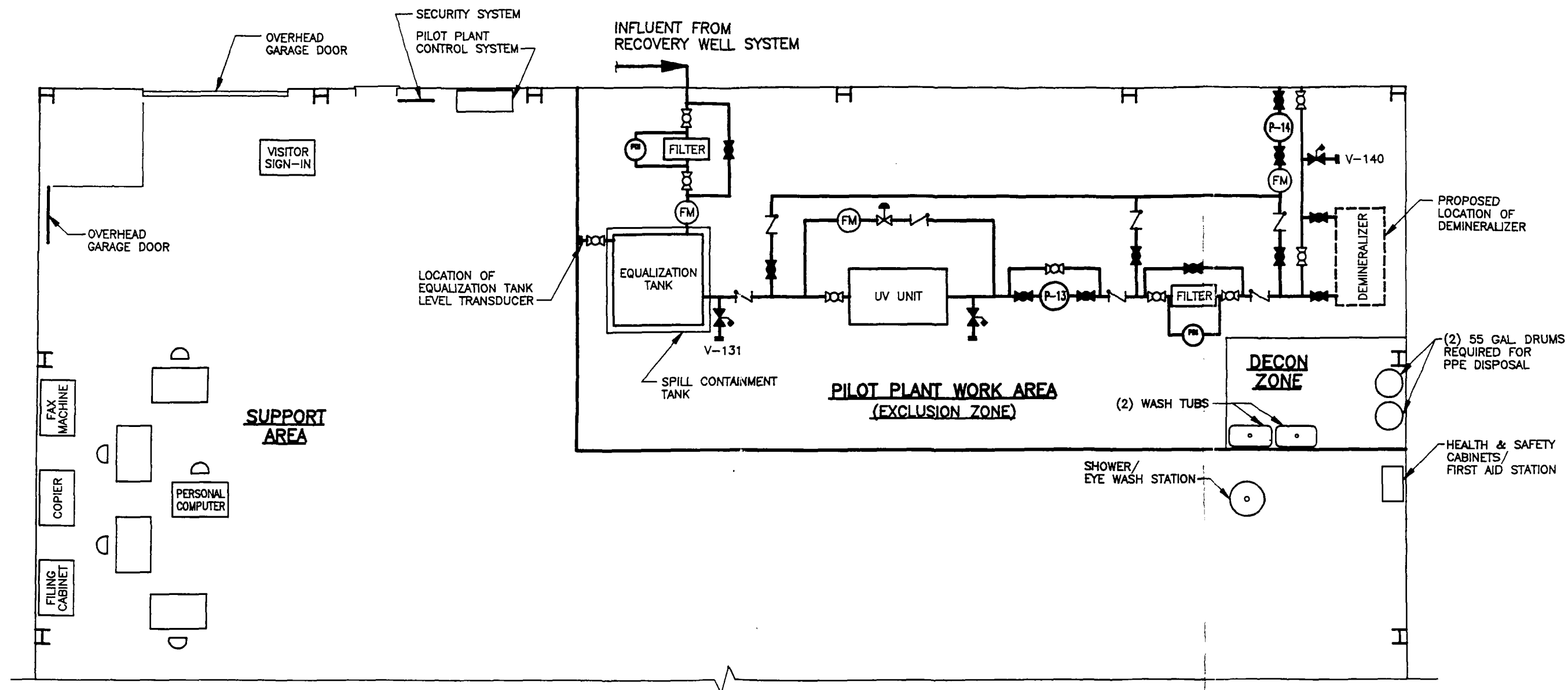
Although this particular experiment appears to have failed for what may be called mechanical reasons, other lab and field experiments have provided positive results. Therefore, additional experiments may be undertaken in the final treatment train for well UC22. These experiments would be configured similarly to that provided during the pilot test. That is, any effluent from the experimental medium would be run through the conventional treatment train to prevent discharge of contaminants should the experimental medium fail.

4.3 Grace Treatability Test

4.3.1 Background

The following sections describe the results of the Grace portion of the treatability test including the pilot treatment plant design, process description, process control and any deviations from the Work Plan (EPC, 1991). The recovery system was installed as indicated on Figure 4.3-1. The pilot treatment plant was constructed within an existing one story metal warehouse on the Grace property as shown on Figure 4.3-2. Ground water was pumped from the existing 10 recovery wells, through the treatment system, and into one of two-30,000 gallon temporary holding tanks. The treated water was then gravity drained to the creek bordering the wetlands, once analytical results verified the quality of the water to be acceptable for discharge.





DRAFT

Remedial Design for the Northeast Quadrant
Wells G & H Site, Woburn, MA

FIGURE 4.3-2
Grace
Pilot Plant Warehouse Plan

Prepared By: **Canonle** Environmental

10/1/91	ISSUED FOR CLIENT REVIEW	JMR/WLJ	HH	
No.	DATE	ISSUE / REVISION	OWN. BY	CK'D BY

4.3.1.1 Design Basis

The pilot plant design was based on six factors:

1. Expected ground-water recovery system flow rate;
2. Specific contaminants to be treated;
3. Expected influent concentration;
4. Pilot plant discharge criteria;
5. Contingencies and complete avoidance of air emissions into the environment;
6. Cost.

Expected Flow Rate

As indicated in the Work Plan and described in Section 2.0, each recovery well was expected to produce approximately one gallon per minute (gpm), for a total pilot plant flow rate of 10 gpm.

Specific Contaminants to be Treated and Expected Influent Concentration

The specific contaminants to be treated, as indicated in the Record of Decision (ROD) and the Consent Order, and the anticipated influent concentration for the Grace property are:

<u>Contaminant of Concern</u>	<u>Expected Influent Concentration</u>
Trichloroethene	1,500 microgram per liter ($\mu\text{g/L}$)
trans-1,2-Dichloroethene	2,000 $\mu\text{g/L}$
Tetrachloroethene	10 $\mu\text{g/L}$
Vinyl chloride	1,000 $\mu\text{g/L}$
1,2-Dichloroethane	5 $\mu\text{g/L}$
1,1-Dichloroethene	5 $\mu\text{g/L}$
bis(2-Ethyhexyl) phthalate	50 $\mu\text{g/L}$

The total organic compounds concentration was not expected to exceed 5,000 $\mu\text{g/L}$.

Discharge Criteria

The discharge criteria was determined by the EPA, as indicated in the Work Plan, to be the limits established by the Fresh Water Acute Criteria for Aquatic Life (FWACAL). These criteria are listed in Table 4.3-1. Although the ROD for the Grace property stipulated only seven contaminants of concern, Grace also analyzed samples for a broad spectrum of parameters to ensure that the levels of other compounds were also below the levels set by the FWACAL.

Therefore, the analyte list included the complete list of organics identified in the EPA Contract Laboratory Program (CLP) Statement of Work (SOW) for Organics, February 1988 (volatile organic compounds (VOC), semi-VOC, pesticides and PCB); the complete list of inorganics identified in the EPA CLP SOW for Inorganics, July 1988 (metals and cyanide); hexavalent and total chromium, total organic carbon, total dissolved solids, alkalinity, chloride, fluoride, silica, sulfate, nitrate and nitrite nitrogen, and phosphorus.

Contingencies and Avoidance of Air Emissions

The design was required to incorporate contingencies in the event that any of these contaminants exceeded the FWACAL. The design was also required to ensure that no air emissions would come from the treatment of contaminated ground water, based specifically upon the concern that vinyl chloride not be emitted into the atmosphere. Design provisions for these items are described in Section 4.3.1.3.

Cost

Finally, the design had to incorporate the most cost-effective method or combination of methods of treatment and still meet the objectives of the study.

4.3.1.2 Ground-Water Extraction System

The ground-water extraction system for the treatability study on the Grace property consisted of two sets of recovery wells labeled Area One (source wells) and Area Two (down gradient property boundary wells).

Area One: Area one was comprised of six-closely spaced (<20 feet) wells located near a former drainage ditch adjacent to the main building (Figure 4.3-1). This is the major contaminant source area on the Grace property and contaminant concentrations generally decrease with depth and distance away from the ditch. The hydraulic conductivity of the unconsolidated deposits and bedrock is typically less than one foot per day. The primary objective of this line of wells (labeled source area wells) is contaminant mass removal.

TABLE 4.3-1

Analyte List
Fresh Water Acute Criteria for Aquatic Life
(all concentrations in micrograms per liter)

Volatiles	FWACAL	Semi-volatiles	FWACAL	Semi-volatiles (cont)	FWACAL	Pesticides/PCBs	FWACAL	Metals	FWACAL
Vinyl chloride	*	Phenol	10200	2,4-Dinitrotoluene	*	alpha-BHC	(l)	Aluminum	*
Chloroethane	*	bis(2-Chloroethyl)ether	*	Diethylphthalate	(j)	beta-BHC	(l)	Antimony	9000
Methylene chloride	(e)	2-Chlorophenol	4380	4-Chlorophenyl-phenyl ether	*	delta-BHC	(l)	Arsenic (tri-)	360
1,1-Dichloroethene	(b)	1,3-Dichlorobenzene	(h)	Fluorene	(k)	gamma-BHC (lindane)	2.0	(pent-)	850
1,1-Dichloroethane	*	1,4-Dichlorobenzene	(h)	4-Nitroaniline	*	Heptachlor	0.52	Barium	*
trans-1,2-Dichloroethene	(b)	Benzyl alcohol	*	4,6-Dinitro-2-methylphenol	*	Aldrin	3.0	Beryllium	130
cis-1,2-Dichloroethene	(b)	1,2-Dichlorobenzene	(h)	N-nitrosodiphenylamine	*	Heptachlor epoxide	*	Cadmium	3.9 +
Chloroform	28900	2-Methylphenol	*	4-Bromophenyl-phenyl ether	*	Endosulfan I	0.22	Calcium	*
1,2-Dichloroethane	118000	bis(2-Chloroisopropyl)ether	*	Hexachlorobenzene	*	Dieldrin	2.5	Chromium (tri-)	1700 +
1,1,1-Trichloroethane	(g)	4-Methylphenol	*	Pentachlorophenol	20 + +	4,4-DDE	*	(hex-)	16
Carbon tetrachloride	35200	N-nitroso-di-n-propylamine	*	Phenanthrene	(k)	Endrin	0.18	Cobalt	*
Bromodichloromethane	(e)	Hexachloroethane	980	Anthracene	(k)	Endosulfan II	0.22	Copper	18 +
1,2-Dichloropropane	(c)	Nitrobenzene	27000	Di-n-butylphthalate	(j)	4,4-DDD	*	Iron	*
cis-1,3-Dichloropropene	(d)	Isophorone	117000	Fluoranthene	(k)	Endosulfan sulfate	*	Lead	82 +
Trichloroethene	45000	2-Nitrophenol	(i)	Pyrene	(k)	4,4-DDT	1.1	Magnesium	*
Dibromochloromethane	(e)	2,4-Dimethylphenol	2120	Butylbenzylphthalate	(j)	Methoxychlor	*	Manganese	*
1,1,2-Trichloroethane	(g)	Benzoic acid	*	3,3'-Dichlorobenzidine	*	Endrin ketone	*	Mercury	2.4
Benzene	5300	bis(2-Chloroethoxy)methane	*	Benzo(a)anthracene	(k)	alpha-Chlordane	2.4	Nickel	1400 +
trans-1,3-Dichloropropene	(d)	2,4-Dichlorophenol	2020	Chrysene	(k)	gamma-Chlordane	2.4	Potassium	*
Bromoform	(e)	1,2,4-Trichlorobenzene	*	bis(2-Ethylhexyl)phthalate	(j)	Toxaphene	0.73	Selenium	260
Tetrachloroethene	5280	Naphthalene	2300	Di-n-octylphthalate	(j)	Aroclor-1016	(m)	Silver	4.1 +
Toluene	17500	4-Chloroaniline	*	Benzo(b)fluoranthene	(k)	Aroclor-1221	(m)	Sodium	*
1,1,2,2-Tetrachloroethane	(f)	Hexachlorobutadiene	90	Benzo(k)fluoranthene	(k)	Aroclor-1232	(m)	Thallium	1400
Chlorobenzene	(a)	4-Chloro-3-methylphenol	30	Benzo(a)pyrene	(k)	Aroclor-1242	(m)	Vanadium	*
Ethylbenzene	32000	2-Methylnaphthalene	*	Indeno(1,2,3-cd)pyrene	(k)	Aroclor-1248	(m)	Zinc	120 +
o-Xylene	*	Hexachlorocyclopentadiene	7	Dibenz(a,h)anthracene	(k)	Aroclor-1254	(m)		
m-, p-Xylene	*	2,4,6-Trinitrophenol	*	Benzo(g,h,i)perylene	(k)	Aroclor-1260	(m)	Inorganics	
		2,4,5-Trinitrophenol	*					Cyanide	22
Volatile Groups		2-Chloronaphthalene	1600	Semi-volatile Groups		Pesticide Groups		Silica	*
Chlorinated benzenes (a)	250	2-Nitroaniline	*	Dichlorobenzenes (h)	1120	BHCs (l)	*	Nitrite	*
Dichloroethenes (b)	11600	Dimethylphthalate	(j)	Nitrophenols (i)	230	PCBs (m)	0.014	Nitrate	*
Dichloropropanes (c)	23000	Acenaphthylene	*	Phthalate esters (j)	940			Sulfate	*
Dichloropropenes (d)	6060	2,6-Dinitrotoluene	*	PAHs (k)	*	Radionuclides		Fluoride	*
Halomethanes (e)	11000	3-Nitroaniline	*			Gross alpha	*	Chloride	*
Tetrachloroethanes (f)	9320	Acenaphthene	1700			Radium 226/228	*	Phosphate	*
Trichloroethanes (g)	18000	2,4-Dinitrophenol	*			Beta particle	*	Alkalinity	*
		4-Nitrophenol	(i)			Radon	*		
		Dibenzofuran	*			Uranium	*	Others	
								TOC	*
								TDS	*

* : No criteria established

Update #2 to "Quality Criteria for Water 1986", May 1, 1987.

(a-m) : Groups of chemicals for which the criteria is a cumulative total.

+ : Hardness dependant criteria (100 mg/L used).

+ + : pH dependant criteria (7.8 pH used).

Area Two: Area two was comprised of four closely spaced (<20 feet) wells located along the downgradient property boundary. The primary objective of this line of wells (labeled off-site migration wells) is to prevent off-site migration of the contaminant plume in the unconsolidated deposits and shallow bedrock (Figure 4.3-1).

All wells were screened 10 feet in the unconsolidated deposits and the upper 10 feet of the bedrock with the exception of RW4 and RW5. The entire system was designed to maximize the rate of contaminant mass removal and to prevent further migration of contaminated ground water in the unconsolidated deposits and upper bedrock.

A detailed discussion of recovery well placement, screening and hydrogeological response to pumping is contained in Section 3.2. Mean daily flow rates of influent, Area One, Area Two, individual recovery wells, and flow calculations based on totalizer data are contained in Appendix N.

4.3.1.3 Treatment Processes

The selected treatment process for the Grace property was UV/chemical oxidation. This process was chosen for the pilot study for the following reasons:

1. Destruction of VOC - most other treatment technologies involve phase separation (i.e., removal of the contaminant from the water without changing the properties of the molecule itself, and depositing it on another medium such as granular activated carbon);
2. Highly effective treatment method for vinyl chloride;
3. More efficient than carbon adsorption or air stripping for the chemicals on the Grace property;
4. No sludges, spent carbon or regeneration needs;
5. No air emissions;
6. Cost effective.

Technology Description

The UV/chemical oxidation technology employed during the pilot study on the Grace property utilized hydrogen peroxide in the presence of UV light to form hydroxyl radicals, which rapidly

oxidize organic chemicals. Some organic chemicals also degrade by adsorption of UV light alone. The effective destruction of priority pollutant organic chemicals by this process (also known as catalytic oxidation) has been known for some time.

Hydroxyl radicals have a higher relative oxidation potential than chlorine, hydrogen peroxide, or ozone and are slightly less oxidative than fluorine. Due to their oxidative strength, hydroxyl radicals promote the reduction of halogenated hydrocarbons and aromatics, replacing carbon-to-carbon double bonds and halogenated functional groups with oxygen-containing functional groups. The ultimate reduction of these hydrocarbons, if carried to completion, would yield carbon dioxide, water, and inorganic acid (i.e., hydrogen chloride). A more probable scenario includes the formation of organic acids, alcohols, aldehydes, and ketones as intermediate steps, based upon the observed incomplete removal of total organic carbon in the treated water.

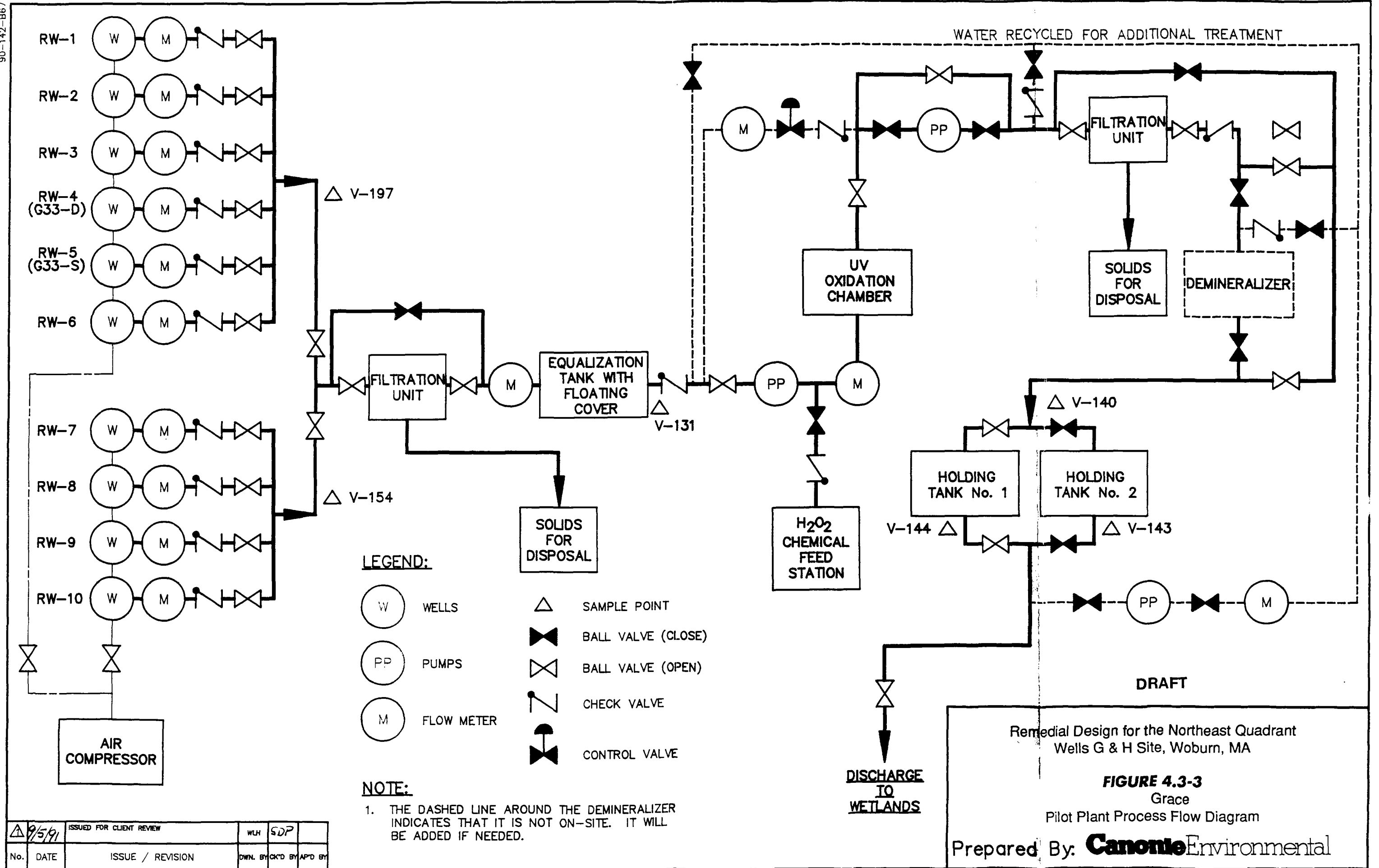
The Rayox Enhanced Oxidation Process, designed by Solarchem Environmental Systems (Solarchem), was a process which eliminated disposal of hazardous organic contaminants as an issue by attaining virtually zero discharge concentrations (i.e., below detection levels) in the effluent when applied at appropriate dosage levels. Factors which directly affect dosage levels include flow rate, hydrogen peroxide concentration, and UV lamp power. Other factors which may promote degradation of organic chemicals in the system include the presence of ozone, low pH, and the presence of ferrous ion.

These three factors which directly affect dosage levels were utilized during the pilot study and evaluated by SolarChem and Canonie during an optimization process where operating conditions for the treatment plant are varied to determine the effect on treatment efficiency. Flow rates, hydrogen peroxide concentrations and effective lamp power were varied in order to ensure maximum levels of treatment with minimal addition of hydrogen peroxide and UV light irradiation. Conclusions were made by SolarChem and Canonie regarding the optimum operating conditions, based upon actual site conditions and results from the optimization study. The optimization study is discussed in Section 4.3.3.5.

The UV/oxidation unit also has a cleaning mechanism designed to avoid problems with solids (typically iron and manganese oxide precipitates) buildup on the quartz glass tube, which surrounds the UV lamp. This mechanism consists of a transmittance controller powered by compressed air which drives a cleaning piston along the quartz tube housing of the UV lamp.

Process Description

The process flow diagram for the pilot plant on the Grace property is shown on Figure 4.3-3.



Ground-water extraction at the Grace property was achieved using 10 ground-water recovery wells as described in Section 4.3.1.2. Figure 4.3-1 shows the well locations. Each well contained a QED Model Number LP1001 submersible pneumatic pump, capable of approximately 231 feet of total discharge head at 1.0 gpm and at 100 pounds per square inch gauge (psig) air pressure. Ground water was pumped through a one-inch poly vinyl chloride (PVC) header pipe to the pilot treatment plant which was housed in the existing warehouse located at the property (see Figure 4.3-1).

Typical well pump installation detail is shown on Figure 4.3-4. All pumps were placed one foot from the bottom of the well. Bubbler probe level controllers for each well were set at three feet below the bedrock surface. This resulted in average pumping levels of 2.5 feet below the bedrock for the source area wells (RW-1 through RW-6). As indicated in Section 3.2, the planned pumping procedure for the off-site migration wells (RW-7 through RW-10) was not achieved. Pump size constraints limited extraction rates to approximately one gpm and therefore the predicted drawdown did not occur.

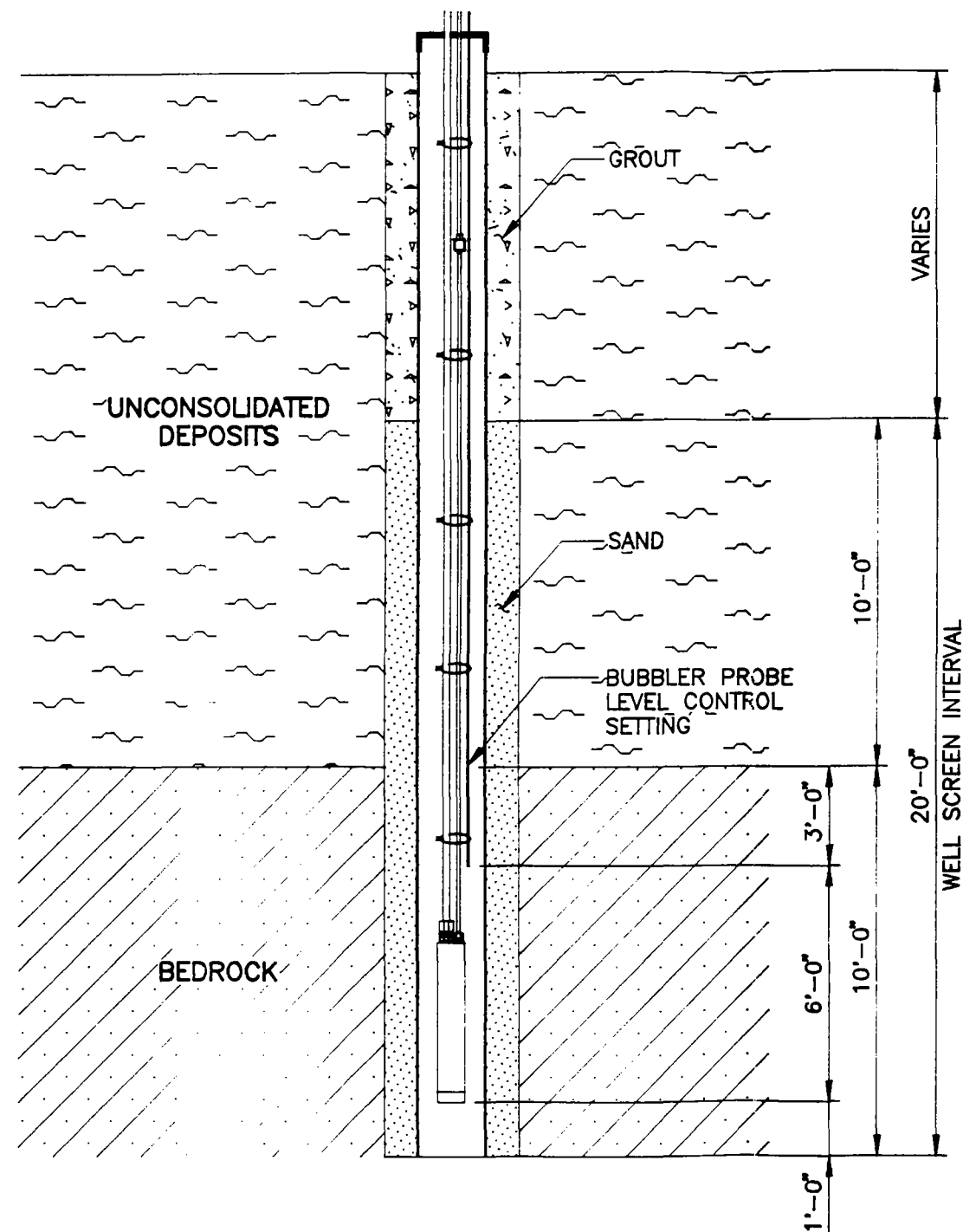
Influent flow from the recovery wells was directed through a 10 micron filtration unit (bag filter) to remove floating and suspended solids in order to prevent a possible decrease in efficiency of the UV/oxidation unit.

After the bag filter, the influent entered a 1,000 gallon airtight equalization tank (EQ) with a floating cover, which provided temporary storage of pumped ground water and suction head for the circulation pump. The tank consisted of a steel frame with two 20-mil PVC liners outside. At the top of the tank, the liners were sealed by three neoprene gaskets and a galvanized steel batten strip. The second liner acted as a floating cover on top of the liquid, allowing the level of the liquid to change without any venting or creation of a pressure/vacuum vessel.

Water flow into the UV/oxidation unit was regulated by a flow control valve. The flow valve controller received inputs from a level transducer in the EQ tank and was set to best accommodate the equilibrium flow from all extraction wells used during the pilot study. The flow valve controller was set to control the range of influent water flow from 5 to 10 gpm.

After treatment by the UV/oxidation unit, the effluent entered a 5 micron bag filter to remove oxidized inorganics from the bag filter. The treated effluent was then discharged to one of the two 30,000 gallon temporary holding tanks.

Demineralizer pipe connections were installed, as indicated on Figure 4.3-2, in the event that the metals concentration in the effluent exceeded the discharge criteria and the contingency plan described in the work plan had to be placed into effect. This never occurred and the demineralizer was never brought on-site.



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FIGURE 4.3-4

Grace

Pilot Plant Well Pump Installation Diagram

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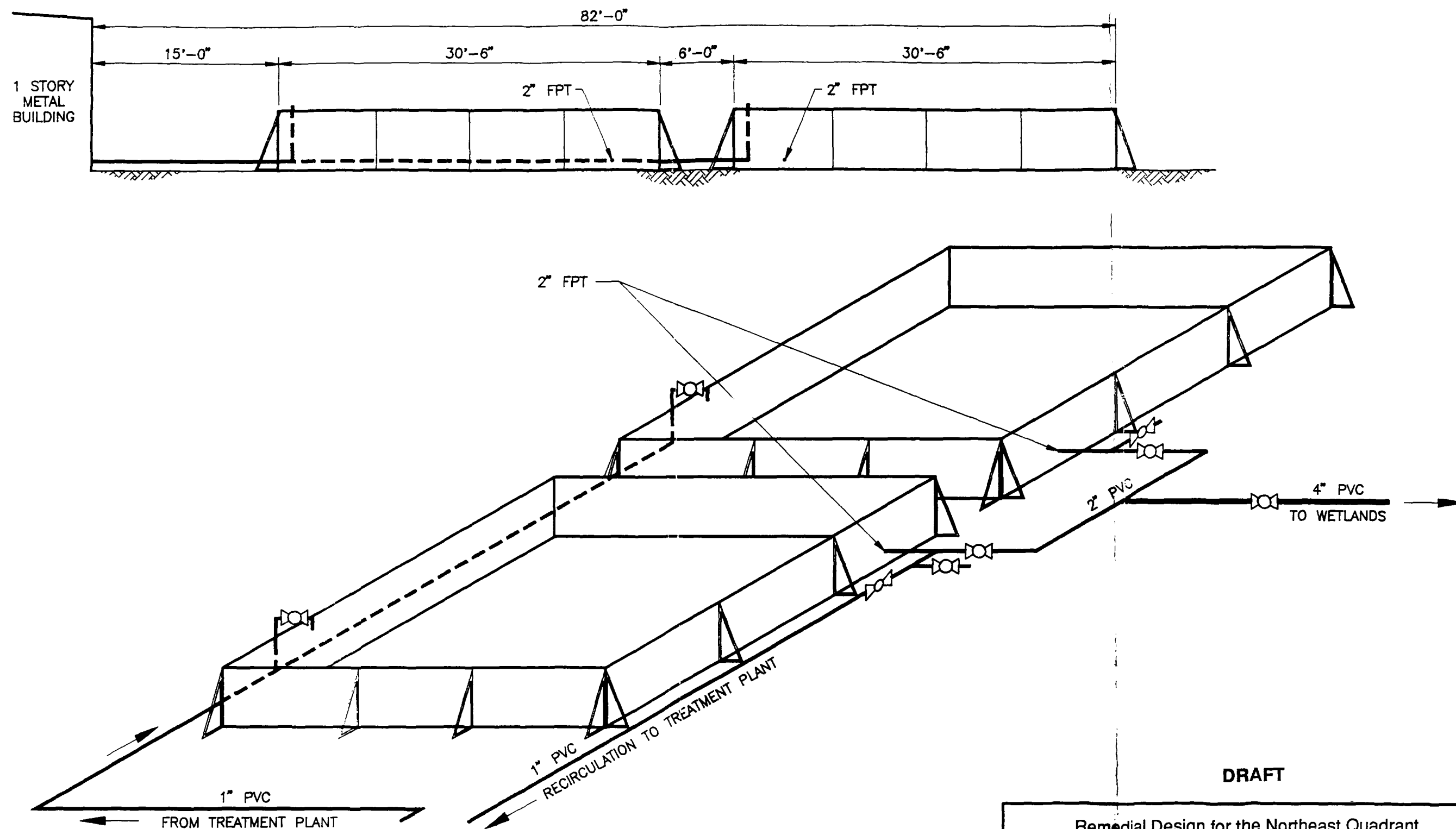
The two temporary holding tanks used during the pilot test are depicted in Figure 4.3-5. The capacity of each temporary holding tank equaled that of a two-day pumping period, or approximately 30,000 gallons. When analytical results of the water in the holding tank showed compliance with the discharge criteria, the daily batch of treated ground water was discharged. All batches of treated ground water met the discharge limits and were released to the unnamed creek bordering the wetlands. Pilot plant analytical results are presented in Section 4.3.3.

4.3.1.4 Control System

The control system used during the pilot study is detailed on the Piping and Instrumentation Diagram (P&ID) given in Figures 4.3-6. The P&ID sheet symbols are contained in Figure 4.3-6A. A proportional-integral-derivative (PID) controller in the treatment process maintained a constant level in the EQ tank. This consisted of an Ametek Model 88C electronic pressure transmitter installed at the base of the EQ tank which sent a variable input signal to a Partlow Corp. Model MIC 2000 process controller as the depth in the tank changed. The controller signalled to a Bellofram Type 1000 transducer which then sent an air signal to a pneumatic control valve (V-168). The valve was composed of a positioner Model PM150, an activator Series 39, and a 3-piece ball valve Series 94. All were manufactured by Worcester Controls. The pneumatic control valve was installed in a recycle line to the UV/oxidation unit. As the water level rose beyond the programmed set point, the control valve would begin to close, sending more of the UV/chemical oxidation unit effluent to the temporary holding tanks. If the level dropped below the programmed set point, the control valve opened, reducing treatment plant discharge and raising the water level in the tank.

If the level in the EQ tank exceeded a programmed set point, an audible alarm would alert the treatment plant operators to the condition and the recovery well pumps would be shut down. During the 10-day pilot study, the control system successfully maintained the depth in the EQ tank at the programmed setpoint and responded correctly by signalling the control valve to any change in the tank depth with no system shutdown.

The recovery wells were installed with a control system which regulated the air to the well pumps and monitored each well pump's operation. QED Inc., the manufacturer of the well pumps, supplied the Pulse Sender Model Number L360 and Well Master Model Number L380. The Pulse Sender took supply air from the compressor and regulated the time for refilling or discharging of the well pumps. There were two Pulse Senders controlling air to the 10 recovery wells, one for recovery wells RW-1 through RW-6 and another for recovery wells RW-7 through RW-10. The refill and discharge time for each cluster during the pilot study is shown as follows:



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NOTES:

1. FITTINGS ARE LOCATED 2" FROM BASE OF TANK.
2. STORAGE TANKS ARE 30,000 GAL 30'-6" x 30'-6" x 4'-9" ECONO TANKS.

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Wells G & H Site, Woburn, MA

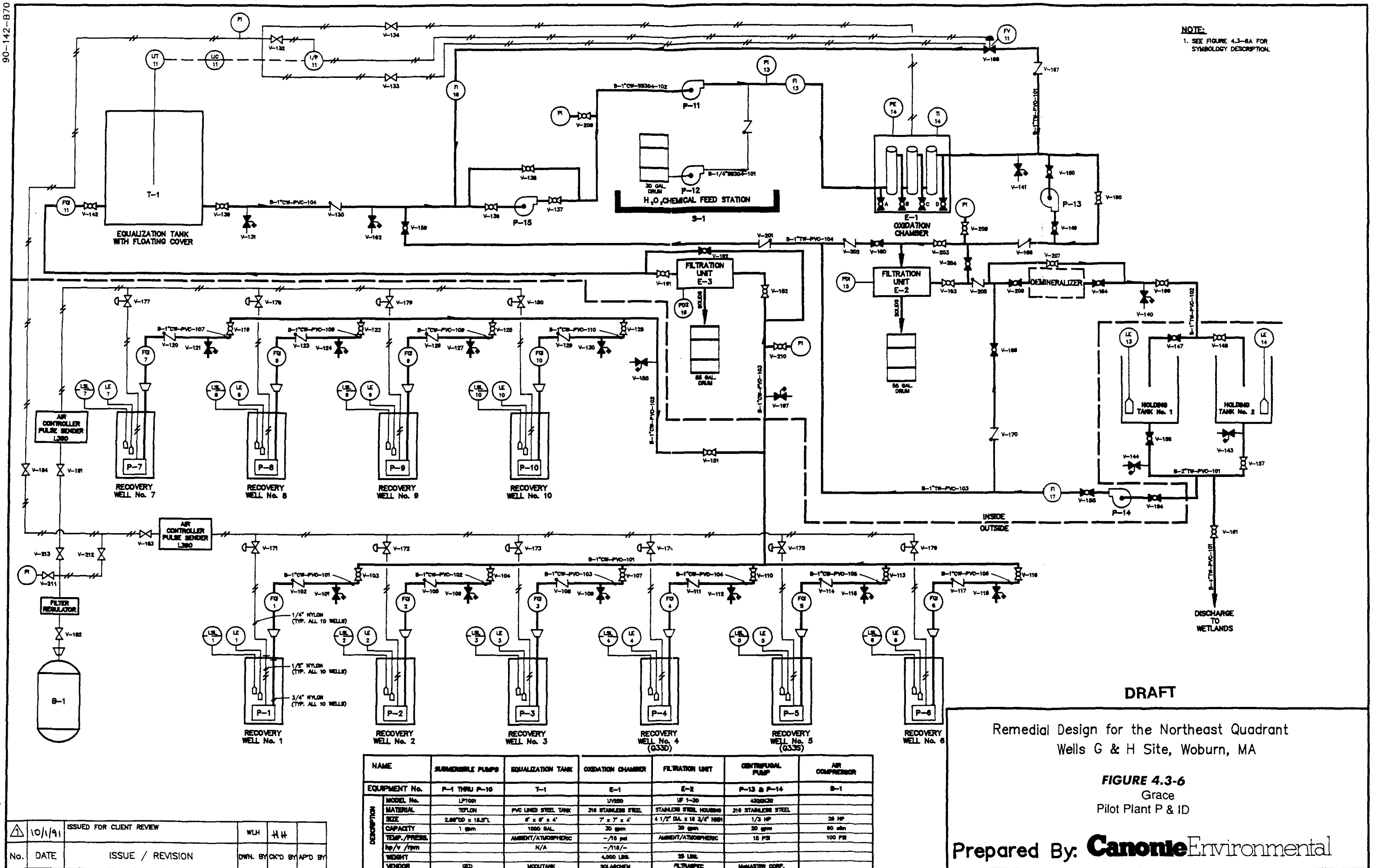
FIGURE 4.3-5

Grace

Pilot Plant Temporary Holding Tank

Prepared By: **Canonie** Environmental

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ANALYSIS	
AAL	ANALYSIS ALARM LOW
AAH	ANALYSIS ALARM HIGH
AE	ANALYSIS ELEMENT
AI	ANALYSIS INDICATOR
AIC	ANALYSIS INDICATING CONTROLLER
AP	ANALYSIS TEST SAMPLE POINT
AR	ANALYSIS RECORDER
ARC	ANALYSIS RECORDING CONTROLLER
AT	ANALYSIS TRANSMITTER
AV	ANALYSIS CONTROL VALVE
AY	ANALYSIS SOLENOID VALVE
FLOW	
FAL	FLOW ALARM LOW
FAH	FLOW ALARM HIGH
FC	FLOW CONTROLLER
FCV	FLOW CONTROL VALVE
FE	FLOW ELEMENT
FFIC	FLOW RATIO INDICATING CONTROLLER
FFRC	FLOW RATIO RECORDING CONTROLLER
FG	FLOW GLASS (SIGHT GLASS)
FI	FLOW INDICATOR
FIC	FLOW INDICATING CONTROLLER
FIT	FLOW INDICATING TRANSMITTER
FO	FLOW RESTRICTION ORIFICE
FBI	FLOW TOTALIZING INDICATOR
FIRC	FLOW TOTALIZING INDICATING CONTROLLER
FIS	FLOW TOTALIZING SWITCH
FIT	FLOW TOTALIZING TRANSMITTER
FR	FLOW RECORDER
FRC	FLOW RECORDING CONTROLLER
FS	FLOW SWITCH
FT	FLOW TRANSMITTER (BLIND)
FV	FLOW CONTROL VALVE
FX	FLOW STRAIGHTENING VANES
FY	LEVEL SOLENOID VALVE
LEVEL	
LAL	LEVEL ALARM LOW
LAM	LEVEL ALARM HIGH
LASH	LEVEL ALARM HIGH-HIGH
LC	LEVEL CONTROLLER (BLIND)
LCV	LEVEL CONTROL VALVE - SELF OPERATOR
LE	LEVEL ELEMENT
LI	LEVEL INDICATOR
LIC	LEVEL INDICATING CONTROLLER
LIH	LEVEL LIGHT HIGH
LIL	LEVEL LIGHT LOW
LR	LEVEL RECORDER
LRC	LEVEL RECORDING CONTROLLER
LS	LEVEL SWITCH
LSH	LEVEL SWITCH HIGH
LSHH	LEVEL SWITCH HIGH-HIGH
LSHL	LEVEL SWITCH HIGH-LOW
LSL	LEVEL SWITCH LOW
LSM	LEVEL SWITCH MEDIUM
LT	LEVEL TRANSMITTER (BLIND)
LIT	LEVEL INDICATING TRANSMITTER
LV	LEVEL CONTROL VALVE
LY	LEVEL SOLENOID VALVE
HUMIDITY OR MOISTURE	
MAL	HUMIDITY ALARM LOW
MAH	HUMIDITY ALARM HIGH
MC	HUMIDITY CONTROLLER (BLIND)
ME	HUMIDITY ELEMENT
MI	HUMIDITY INDICATOR
MIC	HUMIDITY INDICATING CONTROLLER
MR	HUMIDITY RECORDER
MRC	HUMIDITY RECORDING CONTROLLER
MS	HUMIDITY SWITCH
MT	HUMIDITY TRANSMITTER
MY	HUMIDITY CONTROL VALVE
MY	HUMIDITY SOLENOID VALVE

PRESSURE OR VACUUM	
P	PRESSURE TEST POINT
PAH	PRESSURE ALARM HIGH
PAL	PRESSURE ALARM LOW
PCV	PRESSURE CONTROL VALVE
POI	PRESSURE DIFFERENTIAL INDICATOR
POIC	PRESSURE DIFFERENTIAL INDICATING CONTROLLER
POIT	PRESSURE DIFFERENTIAL INDICATING TRANSMITTER
POR	PRESSURE DIFFERENTIAL RECORDER
POIRC	PRESSURE DIFFERENTIAL RECORDING CONTROLLER
POSH	PRESSURE DIFFERENTIAL SWITCH HIGH
POSL	PRESSURE DIFFERENTIAL SWITCH LOW
PI	PRESSURE INDICATOR OR MANOMETER
PIC	PRESSURE INDICATING CONTROLLER
PII	PRESSURE INDICATING TRANSMITTER
PR	PRESSURE RECORDER
PRC	PRESSURE RECORDING CONTROLLER
PRV	PRESSURE REDUCING VALVE - SELF OPERATOR
PS	PRESSURE SWITCH
PSE	RUPTURE DISC OR VACUUM BREAKER
PSH	PRESSURE SWITCH HIGH
PSL	PRESSURE SWITCH LOW
PSV	PRESSURE SAFETY RELIEF VALVE
PT	PRESSURE TRANSMITTER (BLIND)
PV	PRESSURE CONTROL VALVE
PY	PRESSURE SOLENOID VALVE
TEMPERATURE	
TAL	TEMPERATURE ALARM LOW
TAH	TEMPERATURE ALARM HIGH
TCV	TEMPERATURE CONTROL VALVE
TE	TEMPERATURE ELEMENT
TI	TEMPERATURE INDICATOR
TIC	TEMPERATURE INDICATING CONTROLLER
TIS	TEMPERATURE INDICATING SWITCH
TIT	TEMPERATURE INDICATING TRANSMITTER
TR	TEMPERATURE RECORDER
TRC	TEMPERATURE RECORDING CONTROLLER
TS	TEMPERATURE SWITCH
TT	TEMPERATURE TRANSMITTER (BLIND)
TV	TEMPERATURE CONTROL VALVE
TW	TEMPERATURE WELL (TEST)
TY	TEMPERATURE SOLENOID VALVE
PROCESS VARIABLES	
A	ANALYSIS
B	BURNER
C	CONDUCTIVITY
D	SPECIFIC GRAVITY OR DENSITY
E	VOLTAGE
F	FLOW
G	GASING (DIMENSIONAL)
H	HAND/ON HAND
I	CURRENT OR AMMETER
J	POWER
K	TIME, PROGRAM OR COUNTING
L	LEVEL
M	MOISTURE OR HUMIDITY
N	FLAME
P	PRESSURE OR VACUUM
Q	QUANTITY OR EVENT
R	RADIOACTIVITY
S	SPEED OR FREQUENCY
T	TEMPERATURE
U	MULTI-VARIABLE
V	VISCOSITY
W	WEIGHT OR FORCE
X	UNCLASSIFIED
Y	EVENT, STATE
Z	POSITION

MISCELLANEOUS	
ALARM	ALARM ANNUNCIATOR
BC	BURNER CONTROLLER
BV	BURNER CONTROL VALVE
BY	BURNER SOLENOID VALVE
MC	MANUAL CONTROLLER
MIC	MANUAL INDICATING CONTROLLER
MOA	HAND/OFF/AUTO SWITCH
MS	MANUAL SWITCH
MY	MANUAL CONTROL VALVE
MY	MANUAL SOLENOID VALVE
I	CURRENT INDICATOR
I/P	CURRENT TO PNEUMATIC TRANSDUCER
JV	POWER CONTROL VALVE
KC	PROGRAM CONTROLLER
KAPL	NONAQUEOUS PHASE LIQUID
NE	FLAME ARRESTOR
OE	OH ELEMENT
OR	OH INDICATING RECORDER
OT	OH TRANSMITTER
V-20	VALVE NUMBER
XV	COMBUSTION RATE VALVE
YC	EVENT CONTROLLER
YI	INTERFACE INDICATOR
YE	INTERFACE ELEMENT
YL	STATUS LIGHT
YSH	INTERFACE SWITCH HIGH-HIGH
YSL	INTERFACE SWITCH HIGH-LOW
ZI	VALVE POSITION INDICATOR
ZIH	POSITION LIGHT HIGH (OPEN)
ZIL	POSITION LIGHT LOW (CLOSED)
ZS	VALVE POSITION SWITCH
ZZ	POSITION ACTUATOR

LINE SCHEDULE	
STREAM DESCRIPTION	
AA	ATMOSPHERIC AIR
A	AIR - LOW PRESSURE
BAW	BACKWASH OR BACKFLUSH WATER
CA	COMPRESSED AIR
CA	CLEAN DISCHARGE AIR
CTW	CITY WATER
OW	COLLECTED WATER
OR	ORIGIN LINE
HO	HOT OIL STREAM
IA	INSTRUMENT AIR
NG	NATURAL GAS
NBA	NATURAL GAS (HIGH PRESSURE)
NWB	NATURAL GAS (LOW PRESSURE)
OP	ORGANIC PHASE
PW	PLANT WATER
R	REAGENT
RD	REDUCED BYPASS STREAM
RC	REACT CATALYST
RD	REDUCED GAS STREAM
RR	REDUCED RETURN AIR
RW	RAW WATER
SC	SPENT CATALYST
SL	IRON SLUDGE
SLA	SOLVENT LADEN AIR
ST	STEAM
SW	STRIPPED WATER
TW	TREATED WATER
V	VENT
MATERIAL OF CONSTRUCTION	
C2	CARBON STEEL, SCH. 40
C3	CARBON STEEL DUCT, 180
C3	CARBON STEEL, SCH. 80
CU	COPPER TUBING
C90	PVC, AWWA C-900
DP	DUCTILE IRON PIPE
FPP	FIBER REINFORCED PLASTIC
GAL1	GALVANIZED DUCT
GAL2	CARBON STEEL, SCH. 40, GALVANIZED
LI	POLYPROPYLENE LINED STEEL
PPL	POLYPROPYLENE
PVC1	PVC, SCH. 40
PVC2	PVC, SCH. 80
SS304	STAINLESS STEEL DUCT
PIPE INSULATION AND TRACING	
B	BAKE (NO INSULATION)
I	INSULATED
J	INSULATED AND JACKETED
T	STEAM TRACED AND INSULATED
TE	ELECTRICALLY TRACED AND INSULATED

SYMBOLS	
	FLOOR DRAIN
	REDUCER
	ECCENTRIC REDUCER
	STRAINER "Y" TYPE
	FLOOR TRENCH DRAIN
	PIPING (PRIMARY FLOW)
	PIPING (SECONDARY FLOW)
	PNEUMATIC SIGNAL
	ELECTRIC OR ELECTRONIC WIRING
	CAPILLARY TUBE
	HYDRAULIC SIGNAL
	PUMP OR FAN
	CURRENT TO PNEUMATIC VALVE REGULATOR
	VERTICAL TURBINE PUMP
	DIRECTION OF FLOW
	SUBMERSIBLE PUMP
	SECONDARY CONTAINMENT
	LEVEL FLOAT
	MOTOR
	RUPTURED DISC
	FLEXIBLE CONNECTOR
	ARMORED FLEXIBLE CONNECTOR

INSTRUMENT SYMBOLS	
	LOCAL OR FIELD MOUNTED INSTRUMENT
	BEHIND PANEL MOUNTED INSTRUMENT
	PANEL MOUNTED INSTRUMENT
	STATUS LIGHT
	LOCAL PANEL
	MEASURED OR INITIATING VARIABLE
	INSTRUMENT FUNCTION
	INSTRUMENT NUMBER

PROCESS LINE DESCRIPTION	
	LINE NUMBER
	MATERIAL OF CONSTRUCTION
	STREAM DESCRIPTION
	NOMINAL LINE SIZE
	INSULATION AND TRACING (IF ANY)

VALVE OPERATORS	
	BACK PRESSURE
	CHAIN WHEEL
	DIAPHRAGM
	ELECTRIC MOTOR
	EXTENSION STEM AND HANDWHEEL
	GEAR
	HANDLE OR WRENCH
	NON-RISING STEM WITH OPERATING NUT
	PISTON
	PRESSURE REDUCING WITH ADJACENT SET POINT
	RISING STEM HANDWHEEL
	SOLENOID
	4-WAY SOLENOID
	FAIL OPEN
	FAIL CLOSED
	FAIL LOCKED
	FAIL INDETERMINATE
	INTERLOCK (ELECTRICAL)
	BLOCK AND BLEED
	HOSE BIBB
	VENT/SYPHON BREAK

VALVES		
	NORMALLY OPEN	NORMALLY CLOSED
ANGLE GATE		
ANGLE GLOBE		
BALL		
BUTTERFLY		
CHECK		
DAMPER		
DAPHRAM		
ECCENTRIC PLUG		
THREE WAY		
FOUR WAY		
GATE		
GLOBE		
QUICK OPENING SAMPLE VALVE		
PRESSURE/VACUUM RELIEF VALVE		

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FIGURE 4.3-6A

Grace
P&ID Sheet Symbols

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Recovery Well

<u>Cluster</u>	<u>Refill (seconds)</u>	<u>Discharge (seconds)</u>
RW1-RW6	5.0 - 6.0	2.0
RW7-RW10	2.7 - 2.9	2.8

The Well Master for each well was placed inside a locked, wooden box in proximity to the well it controlled. This device regulated the air pressure to the well pump and shut the pump off when the water level in the well reached the bubbler probe level control.

Each of the 30,000-gallon temporary holding tanks had an Omega unit contact alarm attached to its side. When the water surface reached to within three inches of freeboard, an audible alarm sounded alerting the treatment plant operator to a possible overflow condition.

4.3.1.5 Deviations from Work Plan

The Work Plan was followed without exception. The following actions were taken during the treatability study which were not specifically addressed in the Work Plan:

- Well development water was treated at the conclusion of the treatment study using the UV/chemical oxidation process;
- Daily release of the contents of the temporary holding tanks was postponed one to two days due to delays in receipt of the VOC analyses of the process effluent. Temporary holding tank capacities during the study were never exceeded;
- A local security force was present on-site during the study and was maintained for 24 hours a day throughout the study;
- A fence was installed around the 30,000 gallon temporary holding tank with a locking gate to prevent unauthorized entry;
- A fence and New Jersey barriers were installed at the front of the property to deter pedestrians and prevent damage to the well pumps from vehicular traffic;
- Additional sampling was conducted to determine the optimal UV/oxidation system for the final design. These data are presented and discussed in Section 4.3.3.4.

4.3.2 Operations

The treatment plant on the Grace property ran 24 hours per day for 10 days. Canonie operated the treatment plant, performed the sampling required according to the Work Plan, made adjustments to the well pumps, bag filters, and UV/oxidation unit, maintained the health and safety program, and was present on-site during the entire study. A field engineer from Solarchem was present each day to monitor the performance of the UV/oxidation unit and assist Canonie personnel with the treatment plant operations.

4.3.2.1 Startup

Startup of the recovery system and pilot plant treatment included a system shakedown with municipal water to ensure proper operation, repair any leaks, and identify any problems not anticipated. System shakedown occurred on May 6, 1991 through May 9, 1991. All system components operated successfully. Several leaks were identified and repaired.

The Grace portion of the treatability study officially began at 12:00 pm on Friday, May 10, 1991. This was 10 days after the start up of the UniFirst portion of the treatability study. The recovery system well pumps were started at 12:00 pm with the pilot plant starting up at 2:40 pm, two hours and forty minutes after the recovery system. This was done to allow the equalization tank water level to rise to sufficient level to provide an adequate positive suction head for the UV Unit main circulating pump (P-11 Figure 4.3-6).

The recovery system and pilot plant were shut down at 1:00 pm on May 20, 1991, approximately 10 days and 1 hour after startup.

4.3.2.2 Operating Conditions

Operation of the UV/oxidation unit occurred without any problems or interruptions. During normal operations, the treatment plant was operated with two 6-KW UV lamps on, peroxide injection of 40-50 milligrams per liter (mg/L), and a sustained average flow rate of approximately 6 gpm. The recovery system flow data are presented in Appendix N. At any given time, the treatment plant was discharging to one of the 30,000 gallon temporary holding tanks. The water level in the EQ tank was maintained at 42 inches with a few minor exceptions. Security on-site was maintained 24-hours a day and all visitors were logged in.

All analytical samples were taken with the recirculation control valve (V-168) shut off to ensure a representative sample.

Equipment Problems

All equipment performed within the vendor specifications. Most difficulties were those typically encountered during a system startup.

During the 10-day operation, there were three unexpected problems which arose during plant operations.

The first problem was air introduction into the system. The well pumps required adjustment of the discharge and refill timers which controlled the efficiency of the pump. If the refill timer was too short or the discharge timer too long, the discharge from the pump would include air. During inspections of treatment plant operations, the discharge of each well pump was inspected to ensure optimization of flow.

A second problem was a defective flowmeter on RW-5. The flow meter ceased to function on Day 2 of treatment plant operation. Since all other meters were working, the production of RW-5 was calculated by the difference of total influent and the sum of the other nine wells.

A third problem was air buildup in the EQ tank caused by the first problem. This was controlled by monitoring well pump operations and venting the tank. The EQ tank was vented three times during the pilot study. Air emissions surrounding the tank were monitored for VOCs. Personal protective equipment was worn as specified in the Health and Safety Plan (HASP). The results of air monitoring efforts are presented in Section 4.3.2.3. No violations of permissible exposure levels (PELs) were recorded in the workers breathing zone during the venting operations.

4.3.2.3 Monitoring Program

The monitoring program included observation and corrections/adjustments in the recovery well system and treatment plant, maintaining a written record of treatment plant readings to monitor operating conditions, and a sampling schedule designed to meet the objectives outlined in the Quality Assurance/Quality Control (QA/QC) plan.

Daily tasks performed by on-site personnel included:

- Adjust Well Master and Pulse Senders to optimize output of recovery well pumps.
- Record treatment plant data including field measurements of pH and temperature, in the operations log every two to three hours (see Appendix H). This also allowed plant personnel to check for problems throughout the process and take corrective measures.

- Health and Safety matters such as morning meetings, air monitoring near the process and on the site perimeter, logging in of visitors, and air monitoring during sample preparations.
- Maintenance of site security including the integrity of fences, locks, and doors.
- Checking the wetlands to monitor for changes due to the discharge from the temporary holding tanks.
- Checking the temporary holding tank levels.
- Pilot plant sampling.

Daily treatment plant operations also included tasks which occurred occasionally:

- Preparation of analytical and quality control samples on the first, fifth, and tenth day of operations;
- Replace the hydrogen peroxide solution (6 percent) as necessary;
- Replace the bag filter when the pressure drop exceeded 20 psig;
- Repair flow totalizers, gauges, or valves as necessary;
- Air quality sampling and analysis with an on-site gas chromatograph analyzer.

The influent bag filter was changed once during the 10-day pilot study when the pressure drop across the filter was more than 20 psig. This occurred during startup due to sediment accumulation. Changing the influent bag filter took less than 20 minutes and produced no shutdown of the pilot plant operations. The effluent filter bag never required changing during the treatability test.

Wetlands Monitoring

The wetlands on the Grace property were monitored on a continual basis during temporary holding tank discharge. The wetlands monitoring program included:

- Water level monitoring in the creek;
- Peroxide concentration monitoring in the creek;

- Visual inspection for signs of erosion.

The water level in the wetlands did not change during discharge. Peroxide monitoring indicated less than 10 mg/L of peroxide at the entry point into the creek. Monitoring of the creek peroxide concentration revealed non-detectable levels.

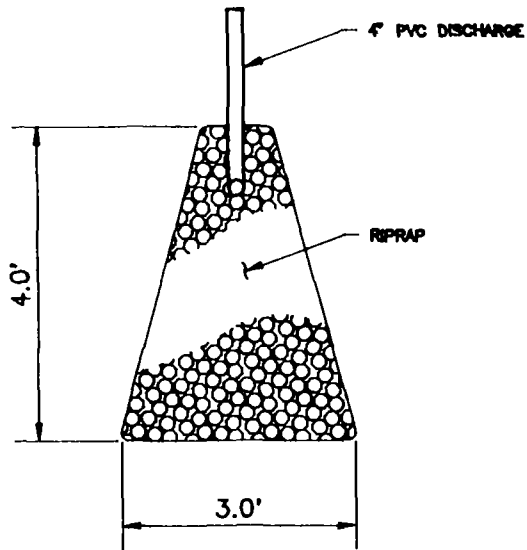
An erosion control structure was designed and constructed to prevent creek bank erosion to the banks of the creek (Figure 4.3-7). This structure effectively reduced the discharge flow to less than one foot per second. No erosion due to temporary holding tank discharge occurred.

4.3.2.4 Health and Safety

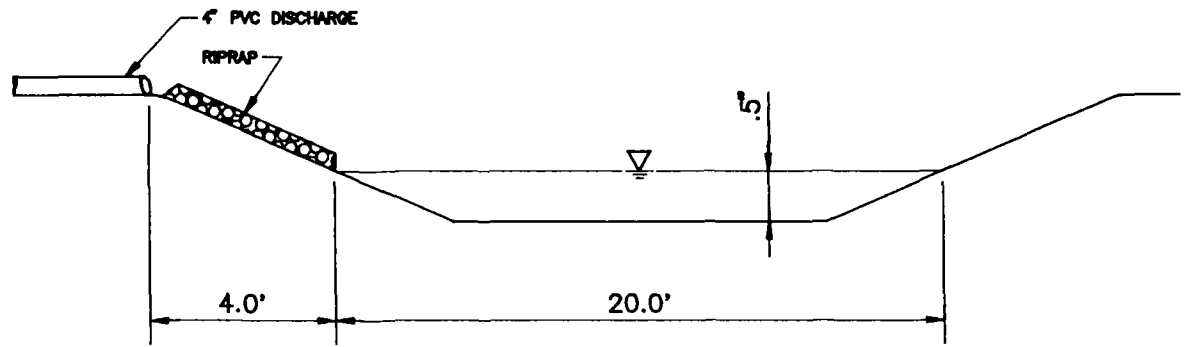
The treatment plant operated by Canonie was essentially a closed system which meant that during normal treatment plant operations, workers were not exposed to untreated ground water. However, during maintenance activities and sampling of influent water, potential for worker exposure did exist. Therefore, Canonie implemented a health and safety and air monitoring program on the Grace property to protect on-site personnel, visitors, and the public from potential physical harm and exposure to hazardous materials.

All activities which presented a potential for contact with contaminated groundwater and/or VOC were monitored by the site safety officer (SSO). These activities were mainly performed between the hours of 7:00 am and 5:00 pm. Beyond this time period, Canonie's on-site engineers implemented the health and safety program with periodic air monitoring of site conditions as presented in Section 6.0 of the approved HASP. The health and safety and air monitoring program was conducted in accordance with the requirements of the approved HASP (January 31, 1991), Amendment 1 to the HASP (May 7, 1991), Amendment 2 to the HASP (May 9, 1991), and Amendment 3 to the HASP (May 17, 1991). This program consisted of:

1. An extensive medical monitoring program that meets and exceeds 29 Code of Federal Regulations (CFR) 1910.120 requirements;
2. 40-hour and 8-hour refresher training for all Canonie personnel, in accordance with 29 CFR 1910.120;
3. First Aid and Cardiopulmonary Resuscitation (CPR) training for on-site Canonie personnel;
4. On-site specific training for anyone entering the Exclusion Zone;
5. An air monitoring and sampling program as presented in this report;



PLAN



SIDE VIEW

Remedial Design for the Northeast Quadrant
Wells G & H Site, Woburn, MA

FIGURE 4.3-7

W.R. Grace
Pilot Study Erosion Control Structure

Prepared By: **Canonle** Environmental

	9/5/91	ISSUED FOR CLIENT REVIEW	WLH	SDP	
No.	DATE	ISSUE / REVISION	OWN.	CK'D BY	AP'D BY

DRAFT

6. Frequent safety inspections to ensure compliance with the HASP and all applicable regulatory requirements.

Applicable Safety Standards

The safety program was implemented in accordance with the approved HASP which required adherence to the Occupational Safety and Health Act (OSHA) general industry standards and OSHA hazardous waste site operations standards. The task of enforcing these standards was the responsibility of the project engineer and the SSO.

OSHA general industry standards were applied during construction of the well recovery system, the EQ tank, the two effluent retention tanks, and all operational activities. Safety measures included electrical safety, warning signs around work zones, housekeeping, and eyewash and emergency shower facilities.

Hazardous waste site operations safety procedures were enforced and included the use of personal protective equipment (PPE), personnel and equipment decontamination procedures, confined space entry procedures, spill contingency procedures, drum handling, and a hazard communication program.

Air Monitoring and Sampling Program

The air monitoring and sampling program was conducted to determine if emissions were released during remedial activities and if so, at what concentration. The data collected during the air monitoring and sampling program were used to evaluate the adequacy of the existing levels of PPE. Air monitoring and air sampling was conducted in the worker breathing zone and in the work area.

The air monitoring and sampling procedures utilized to collect and analyze air samples included the following:

1. Use of direct-reading instruments for field investigation:
 - Portable HN_μ with a 10.2 electron volt (eV) probe for detection of VOC;
 - Combustible gas indicator (CGI) during initial site operations.
2. A Photovac 10S70 portable gas chromatograph (GC) calibrated for the detection of vinyl chloride in air samples;

3. A hybrid National Institute for Occupational Safety and Health (NIOSH) method developed by Roy F. Weston Laboratories utilizing charcoal tubes for the detection of vinyl chloride, trichloroethene, 1, 2-dichloroethane, trans 1,2-dichloroethene, 1,1-dichloroethene, 1,1,1-trichloroethene, and tetrachloroethene;
4. Draeger brand colorimetric detector tubes utilized to detect vinyl chloride. A hand pump was utilized to collect the samples.

Work Area Monitoring

Work area monitoring was conducted at least four times daily with the HN_μ and initially with the CGI to ensure that exposure to VOC did not occur and that adequate PPE was utilized. The action levels specified in the HASP for the levels of PPE were as follows:

1. Background to one part per million (ppm) total VOC above background - Level D;
2. One to fifty ppm of unknown VOC above background - Level "C";
3. Greater than 50 ppm total VOC or vinyl chloride present greater than or equal to 1 ppm - Level "B".

VOC were not detected above background in the work areas during the normal operation of the UV/oxidation unit. VOC were only detected above background in the work area with the HN_μ intermittently during EQ tank maintenance activities and during the drum opening activities. Detections ranged from 0.2 ppm to 1.0 ppm. Workers breathing zones were monitored in the work areas during those activities and the results are discussed below.

Worker Exposure Air Monitoring

Worker breathing zones were monitored on a daily basis during site activities. During startup of treatment plant operations on May 10, 1991, the breathing zones of operators working adjacent to the treatment plant were monitored continuously with the HN_μ and CGI. All activities were conducted in Level "D" PPE on the first day of treatment plant operations except for a brief period when level "C" was utilized by workers in this area as a precautionary measure. The Level "C" PPE was utilized during the release of air from the well recovery system at the influent filter. Unsustained VOC concentrations of 0.2 ppm to 1 ppm were intermittently detected with the HN_μ in the worker breathing zone.

Background levels of VOC in the worker breathing zone were not exceeded during the daily ground-water sampling events or the sounding of wells by the GeoTrans employees. These two

activities were conducted in Level "D" PPE with the use of safety glasses, nitrile gloves, and polytyvek suits or aprons.

Intermittent readings of 0.2 ppm to 1.0 ppm were observed on the HN_μ during the filter bag changing activities, maintenance activities conducted on the EQ tank, and the opening of drums containing purge water. Level "C" PPE was worn as a precautionary measure at all times during the influent and effluent filter bag changing and EQ tank maintenance activities. Both Level "C" and Level "D" PPE were utilized during drum opening activities. The PPE used for Level "C" included a full face respirator with organic vapor/high efficiency particulate air (HEPA) cartridges, nitrile gloves, overboots, and polytyvek suits.

Worker Exposure Air Sampling

Air samples were collected in the worker breathing zone during site activities and included Draeger tubes for vinyl chloride collected with a hand pump, bag samples which were analyzed for vinyl chloride with the Photovac 10S70 GC, and charcoal tube samples which were analyzed by Roy F. Weston Laboratories in accordance with the previously identified method.

Draeger tubes were collected in the worker breathing zone on a daily basis during site activities where potential volatilization of VOC could have occurred. These activities included influent and effluent water sampling, maintenance of the EQ tank, changing of filter bags, and the opening of drums containing purge water. Vinyl chloride was not detected by Draeger tubes in the worker breathing zone during any of these activities.

Worker breathing zone air samples were collected in Tedlar bags and analyzed with the GC on a daily basis during the site activities listed above. The samples were collected for approximately one minute and therefore represent one minute time-weighted average samples. The GC was calibrated for the identification of vinyl chloride using a 1.04 mg/L vinyl chloride calibration gas. Vinyl chloride was only detected in the breathing zone during the venting of air at the influent filter and during the venting of the EQ tank. A summary of vinyl chloride analysis is provided in Appendix O and shows that vinyl chloride was detected in only 8 of 73 samples collected. The maximum concentration of vinyl chloride detected in the breathing zone occurred on May 11, 1991 during venting of the EQ tank and was 1.1 mg/L. This was an instantaneous reading that was not sustained. The sample was taken as the floating cover was initially opened to release trapped air from the EQ tank. Within five minutes, the concentration of vinyl chloride in the breathing zone decreased to 0.121 mg/L. Level "C" PPE was maintained as a precautionary measure.

Worker breathing zone charcoal tube samples were collected once a week on the employee with the greatest potential for exposure to VOC and during each new task. A total of five charcoal

tube samples were collected during treatment plant operations. The analytical results are provided in Appendix O. All five of the charcoal tube samples showed non-detectable levels of VOC.

Perimeter Air Monitoring and Sampling

Perimeter air monitoring and air sampling was conducted on the Grace property to document the impact of activities on the Grace property at perimeter locations. Perimeter locations included areas inside the Grace warehouse at the perimeter of the exclusion zone (which was the support zone around the treatment plant) and outside the warehouse by the site boundary where the well recovery system was located (see Figures 4.3-1 and 4.3-2).

Perimeter locations were monitored twice daily with the HN μ and for four days of treatment plant operation with the CGI. No VOC concentrations above detectable levels were detected for the duration of the project. Once per week, charcoal tube samples were collected at an upwind and downwind perimeter location. However, in accordance with the approved HASP, the samples were analyzed only when direct reading instruments detected compounds in the worker breathing zone. This occurred on May 10, 1991 during the initial venting of air from the influent filter. The charcoal tube samples revealed no detectable levels of VOC.

4.3.2.5 Decommissioning

The pilot treatment plant was decontaminated and dismantled. All contaminated residue, filter sludge, and PPE was properly containerized in 55-gallon drums and is currently stored on the Grace property awaiting proper disposal.

Decontamination of the Treatment Plant

The decontamination of the well recovery system and the UV/oxidation unit was conducted utilizing a well pump and a mixture of municipal water and Alconox detergent. The decontamination mixture was pumped through the treatment plant system to remove any remaining contaminants. Confined space entry procedures were used during decontamination of the EQ tank. Prior to personnel entry, air monitoring was conducted and air samples for GC analysis were collected in the EQ tank. After 15 minutes of venting with a fan, only background levels of VOC were detected in the EQ tank with the HN μ , and vinyl chloride was not detected by the air samples collected and analyzed with the GC.

Two decon water samples, CU7-10 and CU1-6, were collected from the recovery system and analyzed for VOC by EPA Method 524.2 to verify decontamination. The analytical results are given in Appendix G. Results were reported by the laboratory for only one sample, CU7-10. As

indicated in Appendix G for CU1-6, alconox detergent used in decontaminating the recovery system contaminated the column of the GC, causing the column to be inoperable until the alconox could be baked out. However, the results of CU7-10 and air sampling are considered representative of the entire system and, therefore, indicate that the decontamination was successful.

4.3.3 Analytical Results

Executive Summary

The following sections conclude:

1. Only VOC need to be targeted for treatment, specifically vinyl chloride, 1,2-dichloroethene, trichloroethene, and tetrachloroethene;
2. UV oxidation is an effective treatment process for the characterized ground water on the Grace property and the objectives of the pilot study have been completed.

Section 5.2.2 discusses the final selected design for the Grace property and includes UV oxidation as the treatment process.

Water samples were taken throughout the Grace Treatability Test at strategic locations at frequencies as stipulated in the QA/QC Plan.

The sampling and analysis objectives for the Grace pilot plant were:

1. To determine the effectiveness of the UV/chemical oxidation treatment process as an appropriate method of treatment based upon the characterized influent (ground water) from the recovery wells and the discharge limits set by the EPA;
2. To further characterize the source area and off-site migration area wells.

To satisfy these objectives, a sampling and analysis plan was devised and is detailed in Table 4.3-2 and in the QA/QC Plan. Briefly, this plan required daily samples for VOC at four locations which are identified in Figure 4.3-3:

1. Influent from sampling port V-131;
2. Effluent from sampling port V-140;

TABLE 4.3-2

Grace Pilot Plant
Sampling and Analysis Plan

<u>Location (a)</u>	<u>Description</u>	<u>Analytes</u>	<u>Frequency</u>
V-131	Influent	VOCs (b)	Daily
		SVOCs (c)	Day 1, Day 5, and Day 10
		Pesticides/PCBs (d)	Day 1, Day 5, and Day 10
		Metals (e)	Day 1, Day 5, and Day 10
		Nitrate-Nitrite	Day 1, Day 5, and Day 10
		Silica	Day 1, Day 5, and Day 10
		Sulfate	Day 1, Day 5, and Day 10
		Fluoride	Day 1, Day 5, and Day 10
		Phosphate	Day 1, Day 5, and Day 10
		Chloride	Day 1, Day 5, and Day 10
		Alkalinity	Day 1, Day 5, and Day 10
		Total Organic Carbon	Day 1, Day 5, and Day 10
		Total Dissolved Solids	Day 1, Day 5, and Day 10
		Radionuclides	Day 1, Day 5, and Day 10
V-140	Effluent	VOCs - Method 524.2	Daily
		SVOCs (c)	Day 1, Day 5, and Day 10
		Pesticides/PCBs (d)	Day 1, Day 5, and Day 10
		Metals (e)	Day 1, Day 5, and Day 10
		Nitrate-Nitrite	Day 1, Day 5, and Day 10
		Silica	Day 1, Day 5, and Day 10
		Sulfate	Day 1, Day 5, and Day 10
		Fluoride	Day 1, Day 5, and Day 10
		Phosphate	Day 1, Day 5, and Day 10
		Chloride	Day 1, Day 5, and Day 10
		Alkalinity	Day 1, Day 5, and Day 10
		Total Organic Carbon	Day 1, Day 5, and Day 10
		Total Dissolved Solids	Day 1, Day 5, and Day 10
		Radionuclides	Day 1, Day 5, and Day 10
V-154	Recovery Wells 1-6 Influent	VOCs (b)	Daily
V-197	Recovery Wells 7-10 Influent	VOCs (b)	Daily

(a) : Sampling locations are shown on Figure 4.3-3.

(b) : Volatile organic compounds are analyzed by EPA CLP TCL.

(c) : Semi-volatile organic compounds are analyzed by EPA CLP TCL.

(d) : Pesticides/PCBs are analyzed by EPA CLP TCL.

(e) : Metals are analyzed by EPA CLP TAL.

3. Source area recovery wells (RW1-6) from sampling port V-197;
4. Downgradient property boundary recovery wells (RW7-10) from sampling port V-154.

Additionally, samples were taken from V-131 (influent) and V-140 (effluent) on the first, fifth, and tenth days and analyzed for semi-VOC, pesticides/polychlorinated biphenyls (PCB), metals, radionuclides, total organic carbon and miscellaneous inorganics. Also, individual characterization of each of the ten recovery wells for VOC was conducted on samples taken on May 18, 1991.

The sampling and analysis protocol was conducted in accordance with the QA/QC Plan. Analytical results from PACE Laboratories and Aquatec are presented in Appendix G. The QA/QC plan details the sampling and analysis procedures, including sample custody, quality control, data reduction, validation and reporting.

In addition to the influent and effluent sampling which was conducted in accordance with the QA/QC Plan, samples were taken to assist in evaluating various operating conditions and determining the optimal system for the final design. The results of the optimization trials data and an evaluation of the treatment system performance are discussed in Section 4.3.3.4. After the study was completed, sludge samples, which were collected onto filter bags after the treatment system and before the effluent discharge, were analyzed in accordance with the work plan for metals, VOC and radionuclides. The results are discussed in Section 4.3.3.5.

4.3.3.1 Sampling Events Conducted on the First, Fifth, and Final Day

Screening samples were collected three times during the pilot test and analyzed for a full range of organic and inorganic analytes. Laboratory data was received and evaluated based upon the objectives set forth for the project. The goal of the treatability test was to evaluate treatment system performance while maintaining the discharge limits set by the EPA, as indicated in the Work Plan. As part of the complete chemical evaluation, groundwater from the recovery wells was analyzed both before and after UV/oxidation treatment for a wide variety of priority pollutant chemicals and other constituents. With this information available, a treatment process may be selected and designed to target specific chemicals or groups of chemicals which are detected at unacceptably elevated levels above that which is determined to be background levels for the site.

The samples which were analyzed on the first, fifth and tenth days for the parameters identified in Section 4.3.3 were summarized in tabular form and presented in a manner which compares the raw ground-water influent (V-131) directly to the treated effluent (V-140) on Tables 4.3-3 - through 4.3-7. Corresponding field blanks are also presented in these tables. This includes all

methods of analysis which were conducted on these samples with the exception of VOC, which are presented in a separate section. These tables are each identified and discussed herein.

Table 4.3-3 - Semi-Volatile Organics Results

No positively identified semi-VOC were found in the influent or the effluent at any time during the treatability test. An estimated quantity of 1,2-dichlorobenzene (1 µg/L) on Day 1 was rejected in the data validation process by Trillium, Inc.(Trillium). A positively identified quantity of bis (2-ethylhexyl) phthalate in the field blank on Day 1 may be attributable to laboratory contamination. The data indicates that there are no detectable levels of semi-VOC in the ground water. For this reason, semi-VOC are not considered to be part of the final treatment system design.

Table 4.3-4 - Pesticides/PCB Results

No detectable levels of pesticides or PCB were found in the influent, effluent or field blank on any day. The data indicates that there are no detectable levels of pesticides or PCB in the ground water. For this reason, pesticides and PCB are not considered to be part of the final treatment system design.

Table 4.3-5 - Metals and Cyanide Results

Influent and effluent samples were taken, including field blanks, on the first, fifth and tenth day for 24 metals (including hexavalent chromium) and cyanide. The results were below EPA's Contract Required Quantitation Limits (CRQLs) for cyanide and all metals with the exception of calcium, magnesium, sodium, potassium, iron, and manganese. Calcium, magnesium, sodium and potassium are found in a wide range of concentrations in ground water throughout the United States ("Groundwater and Wells", F.G. Driscoll, 2nd Ed., 1986). These metals were determined to be within the normal range of background levels for ground water. The concentrations of these metals were consistent and did not vary significantly (less than 10 percent) between influent and effluent results for all three sampling events.

Iron and manganese are also found, to a lesser degree, in a wide range of concentrations in ground water throughout the United States. Iron concentrations in the influent and effluent were consistent with each other (within 30 percent), but decreased significantly over the 10-day pumping period. The concentration of iron in the ground water influent was reported at 1,420 µg/L on Day 1; 965 µg/L on Day 5; and 208 µg/L on Day 10. This is likely due to the introduction of iron from corrosion of the well casing, which dropped in concentration during the study as the pumping process continued due to flushing of the well casing, thereby providing a more representative sample of the surrounding aquifer. Other metals maintained consistent

TABLE 4.3-3

Grace Pilot Plant
Semi-Volatiles Concentrations

All results in ug/L

SAMPLE ID	V131S1FS	V131S5FS	V131S10FS	V140S1FS	V140S5FS	V140S10FS	V131S1FB	V131S5FB	V131S10FB
SAMPLE LOCATION	INFLUENT V-131			EFFLUENT V-140			FIELD BLANK		
DAY OF RUN	DAY 1	DAY 5	DAY 10	DAY 1	DAY 5	DAY 10	DAY 1	DAY 5	DAY 10
DATE SAMPLED	5/10/91	5/14/91	5/19/91	5/10/91	5/14/91	5/19/91	5/10/91	5/14/91	5/19/91
Phenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
bis(2-Chloroethyl)ether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Chlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,3-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzyl alcohol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichlorobenzene	10 U	1 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Methylphenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
bis(2-Chloroisopropyl)ether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Methylphenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitroso-di-n-propylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Nitrobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Isophorone	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Nitrophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dimethylphenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzoic acid	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
bis(2-Chloroethoxy)methane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dichlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2,4-Trichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Naphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Chloroaniline	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorobutadiene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Chloro-3-methylphenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Methylnaphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorocyclopentadiene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4,6-Trichlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4,5-Trichlorophenol	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
2-Chloronaphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Nitroaniline	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Dimethylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acenaphthylene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,6-Dinitrotoluene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

See Table 4.3-32 for an explanation of the data qualifiers.

Laboratory results are located in Appendix G.

TABLE 4.3-3 (cont.)

All results in ug/L											
SAMPLE ID	V131S1FS	V131S5FS	V131S10FS		V140S1FS	V140S5FS	V140S10FS		V131S1FB	V131S5FB	V131S10FB
SAMPLE LOCATION	INFLUENT V-131				EFFLUENT V-140				FIELD BLANK		
DAY OF RUN	DAY 1	DAY 5	DAY 10		DAY 1	DAY 5	DAY 10		DAY 1	DAY 5	DAY 10
DATE SAMPLED	5/10/91	5/14/91	5/19/91		5/10/91	5/14/91	5/19/91		5/10/91	5/14/91	5/19/91
3-Nitroaniline	50 U	50 U	50 U		50 U	50 U	50 U		50 U	50 U	50 U
Acenaphthene	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
2,4-Dinitrophenol	50 U	50 U	50 U		50 U	50 U	50 U		50 U	50 U	50 U
4-Nitrophenol	50 U	50 U	50 U		50 U	50 U	50 U		50 U	50 U	50 U
Dibenzofuran	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
2,4-Dinitrotoluene	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
Diethylphthalate	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
4-Chlorophenyl-phenylether	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
Fluorene	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
4-Nitroaniline	50 U	50 U	50 U		50 U	50 U	50 U		50 U	50 U	50 U
4,6-Dinitro-2-methylphenol	50 U	50 U	50 U		50 U	50 U	50 U		50 U	50 U	50 U
N-Nitrosodiphenylamine	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
4-Bromophenyl-phenylether	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
Hexachlorobenzene	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
Pentachlorophenol	50 U	50 U	50 U		50 U	50 U	50 U		50 U	50 U	50 U
Phenanthrene	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
Anthracene	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
Di-n-butylphthalate	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
Fluoranthene	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
Pyrene	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
Butylbenzylphthalate	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
3,3'-Dichlorobenzidine	20 U	20 U	20 U		20 U	20 U	20 U		20 U	20 U	20 U
Benzo(a)anthracene	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
Chrysene	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
bis(2-Ethylhexyl)phthalate	10 U	10 U	10 U		10 U	10 U	10 U		61	10 U	10 U
Di-n-octylphthalate	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
Benzo(b)fluoranthene	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
Benzo(k)fluoranthene	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
Benzo(a)pyrene	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
Indeno(1,2,3-cd)pyrene	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
Dibenzo(a,h)anthracene	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U
Benzo(g,h,i)perylene	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U

See Table 4.3-32 for an explanation of the data qualifiers.

Laboratory results are located in Appendix G.

TABLE 4.3-4

Grace Pilot Plant
Pesticides and PCB Concentrations

All results in ug/L

SAMPLE ID	V131P1FS	V131P5FS	V131P10FS	V140P1FS	V140P5FS	V140P10FS	V131P1FB	V131P5FB	V131P10FB
SAMPLE LOCATION	INFLUENT V-131			EFFLUENT V-140			FIELD BLANK		
DAY OF RUN	DAY 1	DAY 5	DAY 10	DAY 1	DAY 5	DAY 10	DAY 1	DAY 5	DAY 10
DATE SAMPLED	5/10/91	5/14/91	5/19/91	5/10/91	5/14/91	5/19/91	5/10/91	5/14/91	5/19/91
alpha-BHC	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U
beta-BHC	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U
delta-BHC	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U
gamma-BHC	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U
Heptachlor	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U
Aldrin	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U
Heptachlor epoxide	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U
Endosulfan I	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U
Dieldrin	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U
4,4'-DDE	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U
Endrin	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U
Endosulfan II	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U
4,4'-DDD	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U
Endosulfan sulfate	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U
4,4'-DDT	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U
Methoxychlor	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U
Endrin ketone	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U
alpha-Chlordane	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U
gamma-Chlordane	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U
Toxaphene	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Aroclor-1016	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U
Aroclor-1221	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U
Aroclor-1232	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U
Aroclor-1242	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U
Aroclor-1248	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U
Aroclor-1254	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Aroclor-1260	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U

See Table 4.3-28 for an explanation of the data qualifiers.

Laboratory results are located in Appendix G.

TABLE 4.3-5

Grace Pilot Plant
Metals and Cyanide Concentrations

All results in ug/L

SAMPLE ID		V131M1FS	V131M5FS	V131M10FS		V140M1FS	V140M5FS	V140M10FS		V131M1FB	V131M5FB	V140M10FB
SAMPLE LOCATION		INFLUENT V-131				EFFLUENT V-140				FIELD BLANK		
DAY OF RUN	CRQL	DAY 1	DAY 5	DAY 10		DAY 1	DAY 5	DAY 10		DAY 1	DAY 5	DAY 10
DATE SAMPLED	(ug/L)	5/10/91	5/14/91	5/19/91		5/10/91	5/14/91	5/19/91		5/10/91	5/14/91	5/19/91
Aluminum	200	195 U	195 U	195 U		210	195 U	195 U		195 U	195 U	195 U
Antimony	60	0.80 U	0.80 U	0.80 U		0.80 U	0.80 U	0.80 U		0.80 U	0.80 U	0.80 U
Arsenic	10	1.9 B	1.5 B	1.0 U		3.6 B	1.5 B	1.0 B		1.0 U	1.0 U	1.0 U
Barium	200	26.0 B	29.0 B	29.0 B		28.0 B	29.0 B	28.0 B		12.5 U	12.5 U	12.5 U
Beryllium	5	1.1 U	1.1 U	1.1 U		1.1 U	1.1 U	1.1 U		1.1 U	1.1 U	1.1 U
Cadmium	5	0.090 B	0.12 B	0.15 B		0.18 B	0.20 B	0.16 B		0.080 U	0.10 B	0.080 U
Calcium	5000	46900	47600	44200		43800	48300	44400		448 U	448 U	448 U
Chromium, total	10	9.5 U	9.5 U	9.5 U		9.5 U	9.5 U	9.5 U		9.5 U	9.5 U	9.5 U
Chromium, hexavalent	-	10 U	10 U *	10 U		10 U	10 U *	10 U		10 U	10 U *	10 U
Cobalt	50	6.4 U	6.4 U	6.4 U		6.4 U	6.4 U	6.4 U		6.4 U	6.4 U	6.4 U
Copper	25	6.0 B	4.5 U	7.0 B		9.0 B	8.0 B	10 B		4.5 U	4.5 U	6.0 B
Iron	100	1420	965	208		1750	882	229		97.7 U	97.7 U	97.7 U
Lead	3	0.80 B	0.50 U	0.80 B		0.70 B	2.3 B	0.50 U		0.60 B	0.90 B	0.50 B
Magnesium	5000	9930	10200	9190		9970	10300	9630		509 U	509 U	509 U
Manganese	15	1160	1300	959		1060	1350	960		1.5 U	1.5 U	1.5 U
Mercury	0.2	0.20 U	0.20 U	0.20 U		0.20 U	0.20 U	0.20 U		0.20 U	0.20 U	0.20 U
Nickel	40	8.6 U	8.6 U	8.6 U		8.6 U	8.6 U	8.6 U		8.6 U	8.6 U	8.6 U
Potassium	5000	7200	6490	7140		7230	6980	7030		760 U	760 U	760 U
Selenium	5	0.50 U	0.50 U	0.50 U		0.50 U	0.50 U	0.50 U		0.50 U	0.50 U	0.50 U
Silver	10	8.1 U	8.1 U	8.1 U		8.1 U	8.1 U	8.1 U		8.1 U	8.1 U	8.1 U
Sodium	5000	30900	28700	30500		30100	30200	28600		390 U	390 U	451 B
Thallium	10	0.70 U	0.70 U	0.70 U		0.70 U	0.70 U	0.70 U		0.70 U	0.70 U	0.70 U
Vanadium	50	5.0 B	4.2 U	4.2 U		4.2 U	4.2 U	4.2 U		4.2 U	4.2 U	4.2 U
Zinc	20	26.0	26.0	22.0		30.0	23.0	23.0		16.0 B	36.0	18.0 B
SAMPLE ID		V131C1FS	V131C5FS	V131C10FS		V140C1FS	V140C5FS	V140C10FS		V131C1FB	V131C5FB	V131C10FB
Cyanide, total	10	10 U	10 U	10 U		10 U	10 U	10 U		10 U	10 U	10 U

CRQL: Contract Required Quantitation Limit

* : Hexavalent chromium results for Day 5 were improperly preserved on Day 5 and resampled on Day 6 for proper analysis.

Hexavalent chromium sample IDs are similar to metals, replacing "M" with "HC".

See Table 4.3-28 for an explanation of the data qualifiers.

Laboratory results are located in Appendix G.

concentrations throughout the treatability test. Manganese concentrations in the influent and effluent on all three days averaged 1,130 µg/L and ranged from 959 µg/L to 1,350 µg/L.

The metals which were detected and identified in the ground water are considered to be naturally occurring; background levels did not exceed the FWACAL. For these reasons, metals are not considered to be part of the treatment system design. An evaluation of the influent and effluent for removal efficiencies of metals indicates no appreciable change in concentration of metals. A 10-micron filter bag installed before the UV/chemical oxidation unit showed an accumulation of solids during the treatability test. This is most likely due to sediment and iron from the well casings.

A five-micron bag filter, installed in sequence after the UV/oxidation unit and prior to the effluent sampling port, did not collect any appreciable amount of solids. The filter showed only a minor differential pressure increase (one to three psi) at the end of 10 days of pumping. Therefore, large amounts of precipitated material are not anticipated and are therefore not a concern for the final design. The analytical results of the solids obtained from both filters are addressed in Section 4.3.3.5.

Table 4.3-6 - Radiological Results

No criteria have been established by FWACAL for radionuclides. The Safe Drinking Water Act (SDWA) established primary drinking water regulations for radioactivity at 5 picoCuries per liter (pCi/L) for Radium-226 and Radium-228 combined, 15 pCi/L for gross alpha particle activity, and 50 pCi/L for gross beta particle activity. The radionuclides were within acceptable limits for influent and effluent samples on all three days.

Table 4.3-7 - Other Water Quality

For the purpose of this summary, "other water quality" include total organic carbon, total dissolved solids, total alkalinity, chloride, total fluoride, dissolved silica, sulfate, nitrate and nitrite nitrogen, and total phosphorus.

Total organic carbon in the influent varied during the study ranging from 4.0 milligram per liter (mg/L) on Day 1 to 1.9 mg/L on Day 5 to 3.4 mg/L on Day 10. The corresponding effluent concentrations were 2.0 mg/L, 1.5 mg/L, and 2.1 mg/L, respectively. The field blanks were reported at 0.9 mg/L, 0.5 mg/L and 0.7 mg/L, respectively. Total organic carbon is typically used as a screening device to determine magnitudes of organic contaminants in water and generally is less informative than the methods used to characterize VOC, semi-VOC, pesticides, and PCB. Results for total organic carbon may be used in conjunction with the other organic methods to assist in the determination of the ultimate fate of the priority pollutant organics in the

TABLE 4.3-6

Grace Pilot Plant
Radionuclide Concentrations

All results in pCi/L

SAMPLE ID	V131R1FS	V131R5FS	V131R10FS		V140R1FS	V140R5FS	V140R10FS		V131R1FB	V131R5FB	V131R10FB
SAMPLE LOCATION	INFLUENT V-131				EFFLUENT V-140				FIELD BLANK		
DAY OF RUN	DAY 1	DAY 5	DAY 10		DAY 1	DAY 5	DAY 10		DAY 1	DAY 5	DAY 10
DATE SAMPLED	5/10/91	5/14/91	5/19/91		5/10/91	5/14/91	5/19/91		5/10/91	5/14/91	5/19/91
Gross Alpha	LT 3.	2.8 +/- 2.7	LT 3.		LT 3.	LT 3.	LT 3.		LT 1.	LT 0.9	LT 3.
Gross Beta	8.9 +/- 2.7	8.9 +/- 3.1	8.9 +/- 2.8		9.3 +/- 2.7	8.8 +/- 3.1	9.6 +/- 2.8		LT 2.	LT 3.	7.3 +/- 2.7
Radium-228	LT 1.	LT 2.	LT 1.		LT 0.8	LT 1.	LT 1.		LT 2.	LT 1.	LT 2.
Radium, total	LT 2.	LT 1.	LT 0.7		LT 2.	LT 1.	1.1 +/- 0.8		LT 2.	LT 1.	0.88 +/- 0.76

LT : Less than

pCi/L : picoCuries per liter

Laboratory results are located in Appendix G.

TABLE 4.3-7

Grace Pilot Plant
Other Water Quality Analytes Concentrations

All results in mg/L									
SAMPLE ID	V131TDS1FS	V131TDS5FS	V131TDS10FS		V140TDS1FS	V140TDS5FS	V140TDS10FS		
SAMPLE LOCATION	INFLUENT V-131				EFFLUENT V-140				FIELD BLANK
DAY OF RUN	DAY 1	DAY 5	DAY 10		DAY 1	DAY 5	DAY 10		DAY 1 DAY 5 DAY 10
DATE SAMPLED	5/10/91	5/14/91	5/19/91		5/10/91	5/14/91	5/19/91		5/10/91 5/14/91 5/19/91
Total Organic Carbon	4	1.9	3.4		2.0	1.5	2.1		0.9 0.5 0.7
Total Dissolved Solids	352	300	312		356	306	330		1 U 1 U 1 U
Alkalinity, total	94	94	87		91	92	87		2 2 2
Chloride	76.6	NA	67.3		78.0	78.6	69.4		1 U 1 U 1 U
Fluoride, total	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U		NA 0.1 U 0.1 U
Silica, dissolved	16.9	16.6	15.3		22.5	18.2	14.4		0.2 U 0.2 U 0.2 U
Sulfate	35.4	32.8	38.5		33.2	34.7	35.4		NA 5 U 5 U
Nitrogen, Nitrate/Nitrite (as N)	3.6	3.1	3.8		4.1	3.5	4.0		0.52 0.10 0.2
Phosphorus, total	0.3 U	0.3 U	0.3 U		0.3 U	0.3 U	0.3 U		0.3 U 0.3 U 0.3 U

Total Organic Carbon sample IDs are similar to Total Dissolved Solids, replacing "TDS" with "TOC".

All results on this table, except TOC, were obtained from the "TDS" sample.

See Table 4.3-28 for an explanation of the data qualifiers.

NA : Not analyzed

Laboratory results are located in Appendix G.

ground water. Table 4.3-9 identifies the VOC concentrations in the influent on each day of the treatment plant operation (Days 1 through 10) and during cleanup and demobilization (Day 11). Using Day 1 as an example, vinyl chloride was detected at 760 $\mu\text{g/L}$; 1,2-dichloroethene was detected at 1,400 $\mu\text{g/L}$; and trichloroethene was detected at 280 $\mu\text{g/L}$. These three volatile compounds were the only organics positively identified in the influent throughout the project (tetrachloroethene was detected and estimated at below 50 $\mu\text{g/L}$) and the sum of these on Day 1 (2,440 $\mu\text{g/L}$ or 2.44 mg/L) compares favorably with the value obtained for Day 1 (4.0 mg/L) for total organic carbon. Table 4.3-13 shows a decrease in the treatment system effluent of all volatile organics identified by the EPA Method 524.2 to below 0.5 $\mu\text{g/L}$.

The remaining analytes identified in Table 4.3-7 are commonly occurring inorganic compounds at levels which are typical of the region and considered to be at background levels. An evaluation of the influent and effluent shows no significant change for any of the parameters for the duration of the project.

Table 4.3-8 - Anion-Cation Balance

An additional quality assurance check used to measure the correctness of inorganic constituent analyses is called an anion-cation balance. As described in "Standard Methods for the Examination of Water and Wastewater, 16th Edition (1985)", the sum of anions, expressed in milliequivalents per liter (meq/L) theoretically must exactly equal the sum of cations in any sample. This is based upon the concept of ionic neutrality in all solutions. The acceptable limits for deviation at the 99 percent confidence level are given by the calculation:

$$(\text{sum of anions}) - (\text{sum of cations}) = + / - [0.1065 + 0.0155 (\text{sum of anions})]$$

Values falling outside these limits indicate a need to recheck one or more determinations. A comparison of the calculated difference between the anions and cations is presented in Table 4.3-8 and compared to the acceptable limits. All values were within the acceptable limits, indicating good comparability of the metals (cation) data to the other inorganic (anion) data. The percent difference of anions and cations ranged from 0.6 to 3.1 percent.

Another applicable procedure for quality assurance on water samples for which relatively complete mineral analyses are made is a comparison of the reported total dissolved solids (TDS), in milligrams per liter, to the sum of the anions and cations which constitute the majority of dissolved solids in a water sample. The two sums should compare favorably; this comparison is typically used to identify discrepancies in the reported data. Table 4.3-8 also compares the reported TDS to the calculated sum of the dissolved ions. The percent difference ranged from 3.3 to 12.5 percent, indicating good comparability of the TDS results to the individual compounds which comprise the total dissolved solids.

TABLE 4.3-8
Anion-Cation Balance

SAMPLE LOCATION DAY OF RUN		V-131						V-140					
		DAY 1		DAY 5		DAY 10		DAY 1		DAY 5		DAY 10	
	FACTOR mg/L-meq/L	Conc. mg/L	Conc. meq/L	Conc. mg/L	Conc. meq/L	Conc. mg/L	Conc. meq/L	Conc. mg/L	Conc. meq/L	Conc. mg/L	Conc. meq/L	Conc. mg/L	Conc. meq/L
Cations													
Calcium	0.0499	46.9	2.34	47.6	2.38	44.2	2.21	43.8	2.19	48.3	2.41	44.4	2.22
Magnesium	0.0823	9.93	0.82	10.2	0.84	9.19	0.76	9.97	0.82	10.3	0.85	9.63	0.79
Sodium	0.0435	30.9	1.34	28.7	1.25	30.5	1.33	30.1	1.31	30.2	1.31	28.6	1.24
Potassium	0.0256	7.2	0.18	6.49	0.17	7.14	0.18	7.23	0.19	6.98	0.18	7.03	0.18
Iron	0.0537	1.42	0.08	0.97	0.05	0.21	0.01	1.75	0.09	0.88	0.05	0.23	0.01
Manganese	0.0364	1.16	0.04	1.3	0.05	0.96	0.03	1.06	0.04	1.35	0.05	0.96	0.03
TOTAL			4.80		4.74		4.52		4.64		4.85		4.47
Anions													
Alkalinity (as HCO ₃)	0.0164	94	1.54	94	1.54	87	1.43	91	1.49	92	1.51	87	1.43
Chloride	0.0282	76.6	2.16	78	2.20	67.3	1.90	78	2.20	78.6	2.22	69.4	1.96
Sulfate	0.0208	35.4	0.74	32.8	0.68	38.5	0.80	33.2	0.69	34.7	0.72	35.4	0.74
Nitrate/ite-N* (as NO ₃)	0.0161	15.9	0.26	13.7	0.22	16.8	0.27	18.2	0.29	15.5	0.25	17.7	0.28
Fluoride	0.0526	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Phosphorus (as PO ₄)	0.0969	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
TOTAL			4.69		4.64		4.40		4.67		4.70		4.41
DIFFERENCE			0.11		0.10		0.12		0.03		0.15		0.06
Acceptable Limit**			0.18		0.18		0.17		0.18		0.18		0.17
% DIFFERENCE			2.3		2.1		2.7		0.6		3.1		1.4
TDS (Laboratory)		352		300		312		356		306		330	
TDS (Calculated)		319		314		302		314		319		300	
% DIFFERENCE			9.8		5.2		3.3		12.5		4.2		9.5

Influent V-131 on Day 5 was not analyzed for chloride; the sample duplicate result of 78 mg/L was used for this evaluation.

* : Nitrate/N results multiplied by 4.427 to obtain nitrate concentration.

** : Acceptable limit, also described as the 99% confidence limit, is identified by the equation:
(0.1065 + 0.0155 (total anions)).

4.3.3.2 Volatile Organics - Influent

Laboratory results for VOC were obtained for the locations which were sampled daily during the Grace treatability test and presented in a manner which compares data from one day to another for each of the four sampling locations identified in Section 4.3.3. Figure 4.3-8 presents the molecular structures of the volatile organic compounds identified in the influent. Tables 4.3-9, 4.3-10, and 4.3-11 present data for the combined influent, source area influent, and off-site migration area influent, respectively. Table 4.3-12 presents data for the ten individual recovery wells which were sampled on May 18, 1991. Table 4.3-13 presents a mass-balance comparison of the individual recovery wells to the two identified influents, as well as the combined influent. These tables are discussed below.

Table 4.3-9 - Volatile Organics - Total Influent

Positively identified VOC in the combined influent include vinyl chloride, 1,2-dichloroethene and trichloroethene. Tetrachloroethene was identified below the reported detection limit on all eleven days and reported as estimates on 3 of the 11 days. One positive result for 2-butanone (110 µg/L on Day 9) was rejected after data validation. Toluene was estimated at 9 µg/L on Day 11. Results for vinyl chloride and 1,2-dichloroethene decreased significantly while trichloroethene increased appreciably during the project.

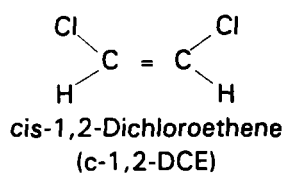
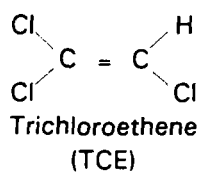
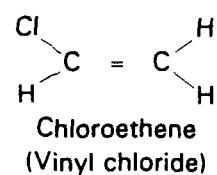
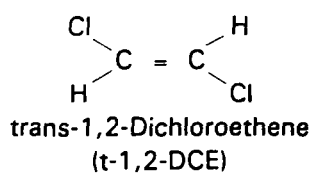
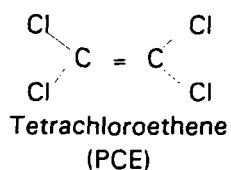
Table 4.3-10 - Volatile Organics - Source Area Influent

Positively identified VOC in the source area influent include vinyl chloride, 1,2-dichloroethene and trichloroethene. In addition, ethylbenzene and toluene were detected and reported near or below the detection limit of 5 µg/L on 5 of the 10 days. Estimated values for tetrachloroethene were reported on Days 8 and 9. Methylene chloride and acetone were each reported on one day and are considered to be laboratory contaminants. In general, vinyl chloride and 1,2-dichloroethene concentrations decreased to approximately one-half their initial concentrations while trichloroethene concentrations increased about fourfold over the 10-day period.

Table 4.3-11 - Volatile Organics - Downgradient Property Boundary

Positively identified VOC in the downgradient property boundary area influent include 1,2-dichloroethene and trichloroethene. Also, tetrachloroethene was reported on two days, estimated at 11 µg/L on Day 3 and qualified at 46 µg/L on Day 8 since it was found in the corresponding blank sample. Acetone was identified at 74 µg/L on Day 3 and is considered to be a laboratory contaminant. The reported concentrations for 1,2-dichloroethene and

W.R. Grace property contaminants of concern



Typical laboratory contaminants

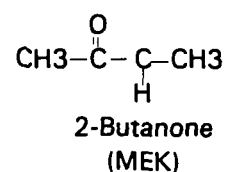
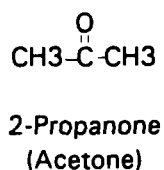
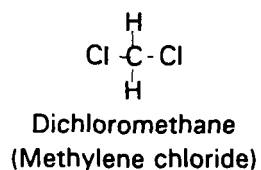


FIGURE 4.3-8

DRAFT

Volatile Organic Compounds
Wells G&H

TABLE 4.3-9

Grace Pilot Plant
Total Influent - (V131)
VOC Concentrations

All results in ug/L

SAMPLE ID	V131V1FS	V131V2FS	V131V3FD	V131V4FS	V131V5FS	V131V6FS	V131V7FS	V131V8FS	V131V9FS	V131V10FS	V131V11FS
DAY OF RUN	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7	DAY 8	DAY 9	DAY 10	DAY 11
DATE SAMPLED	5/10/91	5/11/91	5/12/91	5/13/91	5/14/91	5/15/91	5/16/91	5/17/91	5/18/91	5/19/91	5/20/91
Chloromethane	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	50 U
Bromomethane	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	50 U
Vinyl chloride	760	1100	930	550	570	400	360	360	240	280	340
Chloroethane	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	50 U
Methylene chloride	50 U	64 B	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	23 BJ
Acetone	100 U	100	100 U	100 U	100 U	100 U	78 J	68 BJ	73 BJ	100 U	30 BJ
Carbon disulfide	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U
1,1-Dichloroethene	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U
1,1-Dichloroethane	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U
1,2-Dichloroethene, total	1400	1200	1200	1100	1200	940	930	990	730	830	660
Chloroform	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U
1,2-Dichloroethane	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U
2-Butanone	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	110	100 U	50 U
1,1,1-Trichloroethane	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U
Carbon tetrachloride	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U
Vinyl acetate	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	50 U
Bromodichloromethane	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U
1,2-Dichloropropane	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U
cis-1,3-Dichloropropene	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U
Trichloroethene	280	310	330	360	440	420	430	500	400	410	460
Dibromochloromethane	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U
1,1,2-Trichloroethane	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U
Benzene	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U
trans-1,3-Dichloropropene	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U
Bromoform	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U
4-Methyl-2-pentanone	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	50 U
2-Hexanone	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	50 U
Tetrachloroethene	50 U	16 J	50 U	50 U	50 U	50 U	50 U	50 U	41 J	50 U	12 J
1,1,2,2-Tetrachloroethane	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U
Toluene	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	9 J
Chlorobenzene	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U
Ethylbenzene	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U
Styrene	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U
Xylene, total	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U

See Table 4.3-28 for an explanation of the data qualifiers.

Laboratory results are located in Appendix G.

TABLE 4.3-10

Grace Pilot Plant
Recovery Wells 1-6 Influent - (V197)
VOC Concentrations

All results in ug/L

SAMPLE ID	V197V1FS	V197V2FS	V197V3FS	V197V4FS	V197V5FS	V197V6FS	V197V7FS	V197V8FS	V197V9FS	V197V10FS
DAY OF RUN	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7	DAY 8	DAY 9	DAY 10
DATE SAMPLED	5/10/91	5/11/91	5/12/91	5/13/91	5/14/91	5/15/91	5/16/91	5/17/91	5/18/91	5/19/91
Chloromethane	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U
Bromomethane	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U
Vinyl chloride	1900	2000	1900	1500	1300	1400	1100	1100	760	980
Chloroethane	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U
Methylene chloride	97 B	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Acetone	100 U	30 J	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U
Carbon disulfide	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
1,1-Dichloroethene	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
1,1-Dichloroethane	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
1,2-Dichloroethene, total	2100 E	1900	1400	1700	1600	1700	1600	1600	1100	1300
Chloroform	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
1,2-Dichloroethane	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
2-Butanone	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U
1,1,1-Trichloroethane	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Carbon tetrachloride	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Vinyl acetate	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U
Bromodichloromethane	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
1,2-Dichloropropane	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
cis-1,3-Dichloropropene	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Trichloroethene	41 J	220	63	83	87	50 U	140	220	220	260
Dibromochloromethane	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
1,1,2-Trichloroethane	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Benzene	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
trans-1,3-Dichloropropene	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Bromoform	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
4-Methyl-2-pentanone	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U
2-Hexanone	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U
Tetrachloroethene	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 J	19 J	50 U
1,1,2,2-Tetrachloroethane	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Toluene	50 U	45 J	29 J	30 J	30 J	50 U	50 U	13 J	50 U	50 U
Chlorobenzene	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Ethylbenzene	57	27 J	34 J	30 J	30 J	50 U	50 U	50 U	50 U	50 U
Styrene	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Xylene, total	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U

See Table 4.3-28 for an explanation of the data qualifiers.

Laboratory results are located in Appendix G.

TABLE 4.3-11

Grace Pilot Plant
Recovery Wells 7-10 Influent - (V154)
VOC Concentrations

All results in ug/L

SAMPLE ID	V154V1FS	V154V2FS	V154V3FS	V154V4FS	V154V5FS	V154V6FS	V154V7FS	V154V8FS	V154V9FS	V154V10FS
DAY OF RUN	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7	DAY 8	DAY 9	DAY 10
DATE SAMPLED	5/10/91	5/11/91	5/12/91	5/13/91	5/14/91	5/15/91	5/16/91	5/17/91	5/18/91	5/19/91
Chloromethane	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U	50 U	50 U
Bromomethane	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U	50 U	50 U
Vinyl chloride	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U	50 U	50 U
Chloroethane	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U	50 U	50 U
Methylene chloride	25 U	25 U	25 U	25 U	25 U	25 U	25 U	12 U	25 U	25 U
Acetone	50 U	50 U	74	50 U	50 U	50 U	50 U	25 U	50 U	50 U
Carbon disulfide	25 U	25 U	25 U	25 U	25 U	25 U	25 U	12 U	25 U	25 U
1,1-Dichloroethene	25 U	25 U	25 U	25 U	25 U	25 U	25 U	12 U	25 U	25 U
1,1-Dichloroethane	25 U	25 U	25 U	25 U	25 U	25 U	25 U	12 U	25 U	25 U
1,2-Dichloroethene, total	480	420	340	320	450	470	430	380	450	370
Chloroform	25 U	25 U	25 U	25 U	25 U	25 U	25 U	12 U	25 U	25 U
1,2-Dichloroethane	25 U	25 U	25 U	25 U	25 U	25 U	25 U	12 U	25 U	25 U
2-Butanone	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U	50 U	50 U
1,1,1-Trichloroethane	25 U	25 U	25 U	25 U	25 U	25 U	25 U	12 U	25 U	25 U
Carbon tetrachloride	25 U	25 U	25 U	25 U	25 U	25 U	25 U	12 U	25 U	25 U
Vinyl acetate	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U	50 U	50 U
Bromodichloromethane	25 U	25 U	25 U	25 U	25 U	25 U	25 U	12 U	25 U	25 U
1,2-Dichloropropane	25 U	25 U	25 U	25 U	25 U	25 U	25 U	12 U	25 U	25 U
cis-1,3-Dichloropropene	25 U	25 U	25 U	25 U	25 U	25 U	25 U	12 U	25 U	25 U
Trichloroethene	440	450	410	300	440	480	400	300	440	360
Dibromochloromethane	25 U	25 U	25 U	25 U	25 U	25 U	25 U	12 U	25 U	25 U
1,1,2-Trichloroethane	25 U	25 U	25 U	25 U	25 U	25 U	25 U	12 U	25 U	25 U
Benzene	25 U	25 U	25 U	25 U	25 U	25 U	25 U	12 U	25 U	25 U
trans-1,3-Dichloropropene	25 U	25 U	25 U	25 U	25 U	25 U	25 U	12 U	25 U	25 U
Bromoform	25 U	25 U	25 U	25 U	25 U	25 U	25 U	12 U	25 U	25 U
4-Methyl-2-pentanone	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U	50 U	50 U
2-Hexanone	50 U	50 U	50 U	50 U	50 U	50 U	50 U	25 U	50 U	50 U
Tetrachloroethene	25 U	25 U	11 J	25 U	25 U	25 U	25 U	46 B	25 U	25 U
1,1,2,2-Tetrachloroethane	25 U	25 U	25 U	25 U	25 U	25 U	25 U	12 U	25 U	25 U
Toluene	25 U	25 U	25 U	25 U	25 U	25 U	25 U	12 U	25 U	25 U
Chlorobenzene	25 U	25 U	25 U	25 U	25 U	25 U	25 U	12 U	25 U	25 U
Ethylbenzene	25 U	25 U	25 U	25 U	25 U	25 U	25 U	12 U	25 U	25 U
Styrene	25 U	25 U	25 U	25 U	25 U	25 U	25 U	12 U	25 U	25 U
Xylene, total	25 U	25 U	25 U	25 U	25 U	25 U	25 U	12 U	25 U	25 U

See Table 4.3-28 for an explanation of the data qualifiers.

Laboratory results are located in Appendix G.

trichloroethene were consistent throughout the 10-day period and showed no discernable change during that time.

Table 4.3-12 - Volatile Organics - Individual Recovery Wells

The ten recovery wells were sampled individually on May 18, 1991 (Day 9) and analyzed in order to further characterize the source area and off-site migration area wells. RWs 1 through 6 are located in the source area. RWs 7 through 10 are located in the downgradient property boundary area.

Table 4.3-13 - Mass Balance Calculations

Mass balance calculations combine the concentration and flow of each individual recovery well for comparability with results obtained from the source area influent and the off-site migration area influent, and additionally to the total combined influent. This mass balance comparison is presented in Table 4.3-13. Figure 4.3-9 presents the cumulative total organic mass which entered the treatment system and was destroyed by the UV/oxidation unit.

4.3.3.3 Volatile Organics - Effluent

Table 4.3-14 - Volatile Organics - Effluent Results

VOC in the effluent were analyzed by EPA Method 524.2 rather than the CLP method in order to obtain lower method detection limits, thereby giving greater assurance that the effluent would meet the established discharge criteria and provide more information to assess treatment efficiency. No volatile organics were detected at, or greater than, 0.5 µg/L throughout Days 1 to 8. On Day 9, positive values for vinyl chloride (2.4 µg/L), 1,2-dichloroethene (12.1 µg/L) and trichloroethene (8.2 µg/L) were detected because the treatment system was operated at a lower UV dosage. However, the values were still below the FWACAL discharge criteria. Results for Day 10 indicated chloroethane at 1.5 µg/L, which may be a breakdown product of vinyl chloride, 1,2-dichloroethene, and trichloroethene. Also detected on Day 10 were 1,2-dichloroethene (0.9 µg/L) and trichloroethene (0.6 µg/L). Results from Day 11 indicated an estimated quantity of trichloroethene (0.3 µg/L); and methylene chloride (1.0 µg/L), which was also found in the associated blank and considered to be a laboratory contaminant.

Treatment system effluent characterization is the most critical area of the entire treatability study. The design criteria for the treatment plant is to reduce or eliminate hazardous chemicals from the ground water to acceptable levels before the water is discharged into the environment. Previous tables addressed semi-volatiles, pesticides/PCB, metals, inorganics and radionuclides, pointing to the conclusion that these compounds are not of concern to the design of the

TABLE 4.3-12

Grace Pilot Plant
Individual Recovery Wells
VOC Concentrations

All results in ug/L

SAMPLE ID	RW-1	RW-2	RW-3	RW-4	RW-5	RW-6	RW-7	RW-8	RW-9	RW-10
DATE SAMPLED	5/18/91	5/18/91	5/18/91	5/18/91	5/18/91	5/18/91	5/18/91	5/18/91	5/18/91	5/18/91
EPA METHOD	CLP	CLP	CLP	CLP	CLP	CLP	CLP	CLP	CLP	CLP
Chloromethane	35 U	23 U	80 U	43 U	43 U	120 U	61 U	22 U	14 U	25 U
Bromomethane	35 U	23 U	80 U	43 U	43 U	120 U	61 U	22 U	14 U	25 U
Vinyl chloride	2200 D	870 D	710	730	46	720	61 U	2 J	14 U	25 U
Chloroethane	35 U	23 U	19 J	13 J	43 U	34 J	61 U	22 U	14 U	25 U
Methylene chloride	6 J	8 BJ	17 J	21 U	5 BJ	24 BJ	17 BJ	3 BJ	3 BJ	8 BJ
Acetone	35 U	13 BJ	80 U	43 U	43 U	120 U	100 B	4 BJ	14 U	14 BJ
Carbon disulfide	17 U	11 U	40 U	21 U	22 U	58 U	30 U	11 U	7 U	12 U
1,1-Dichloroethene	5 U	11 U	40 U	21 U	22 U	58 U	30 U	11 U	7 U	12 U
1,1-Dichloroethane	17 U	11 U	40 U	21 U	22 U	58 U	30 U	11 U	7 U	12 U
1,2-Dichloroethene, total	3600 D	960 D	1300	1200 D	360	1800	320	250	230	280
Chloroform	17 U	11 U	40 U	21 U	22 U	58 U	30 U	11 U	7 U	12 U
1,2-Dichloroethane	17 U	11 U	40 U	21 U	22 U	58 U	30 U	11 U	7 U	12 U
2-Butanone	35 U	23 U	80 U	43 U	43 U	120 U	1300 D	13 J	14 U	25 U
1,1,1-Trichloroethane	17 U	11 U	40 U	21 U	22 U	58 U	30 U	11 U	7 U	12 U
Carbon tetrachloride	17 U	11 U	40 U	21 U	22 U	58 U	30 U	11 U	7 U	12 U
Vinyl acetate	35 U	23 U	80 U	43 U	43 U	120 U	61 U	22 U	14 U	25 U
Bromodichloromethane	17 U	11 U	40 U	21 U	22 U	58 U	30 U	11 U	7 U	12 U
1,2-Dichloropropane	17 U	11 U	40 U	21 U	22 U	58 U	30 U	11 U	7 U	12 U
cis-1,3-Dichloropropene	17 U	11 U	40 U	21 U	22 U	58 U	30 U	11 U	7 U	12 U
Trichloroethene	310	250	1300	360	510	660	540	310	160	180
Dibromochloromethane	17 U	11 U	40 U	21 U	22 U	58 U	30 U	11 U	7 U	12 U
1,1,2-Trichloroethane	17 U	11 U	40 U	21 U	22 U	58 U	30 U	11 U	7 U	12 U
Benzene	17 U	11 U	40 U	21 U	22 U	58 U	30 U	11 U	7 U	12 U
trans-1,3-Dichloropropene	17 U	11 U	40 U	21 U	22 U	58 U	30 U	11 U	7 U	12 U
Bromoform	17 U	11 U	40 U	21 U	22 U	58 U	30 U	11 U	7 U	12 U
4-Methyl-2-pentanone	35 U	23 U	80 U	43 U	43 U	120 U	61 U	22 U	14 U	25 U
2-Hexanone	35 U	23 U	80 U	43 U	43 U	120 U	61 U	22 U	14 U	25 U
Tetrachloroethene	10 J	11 J	29 J	7 J	13 J	19 J	13 J	9 J	4 J	6 J
1,1,2,2-Tetrachloroethane	17 U	11 U	40 U	21 U	22 U	58 U	30 U	11 U	7 U	12 U
Toluene	220	6 J	40 U	21 U	22 U	58 U	30 U	11 U	7 U	12 U
Chlorobenzene	17 U	3 J	40 U	21 U	22 U	58 U	30 U	11 U	7 U	12 U
Ethylbenzene	37	11 U	40 U	21 U	22 U	58 U	30 U	11 U	7 U	12 U
Styrene	17 U	11 U	40 U	21 U	22 U	58 U	30 U	11 U	7 U	12 U
Xylene, total	36	11 U	40 U	21 U	22 U	58 U	30 U	11 U	7 U	12 U

See Table 4.3-28 for an explanation of the data qualifiers.

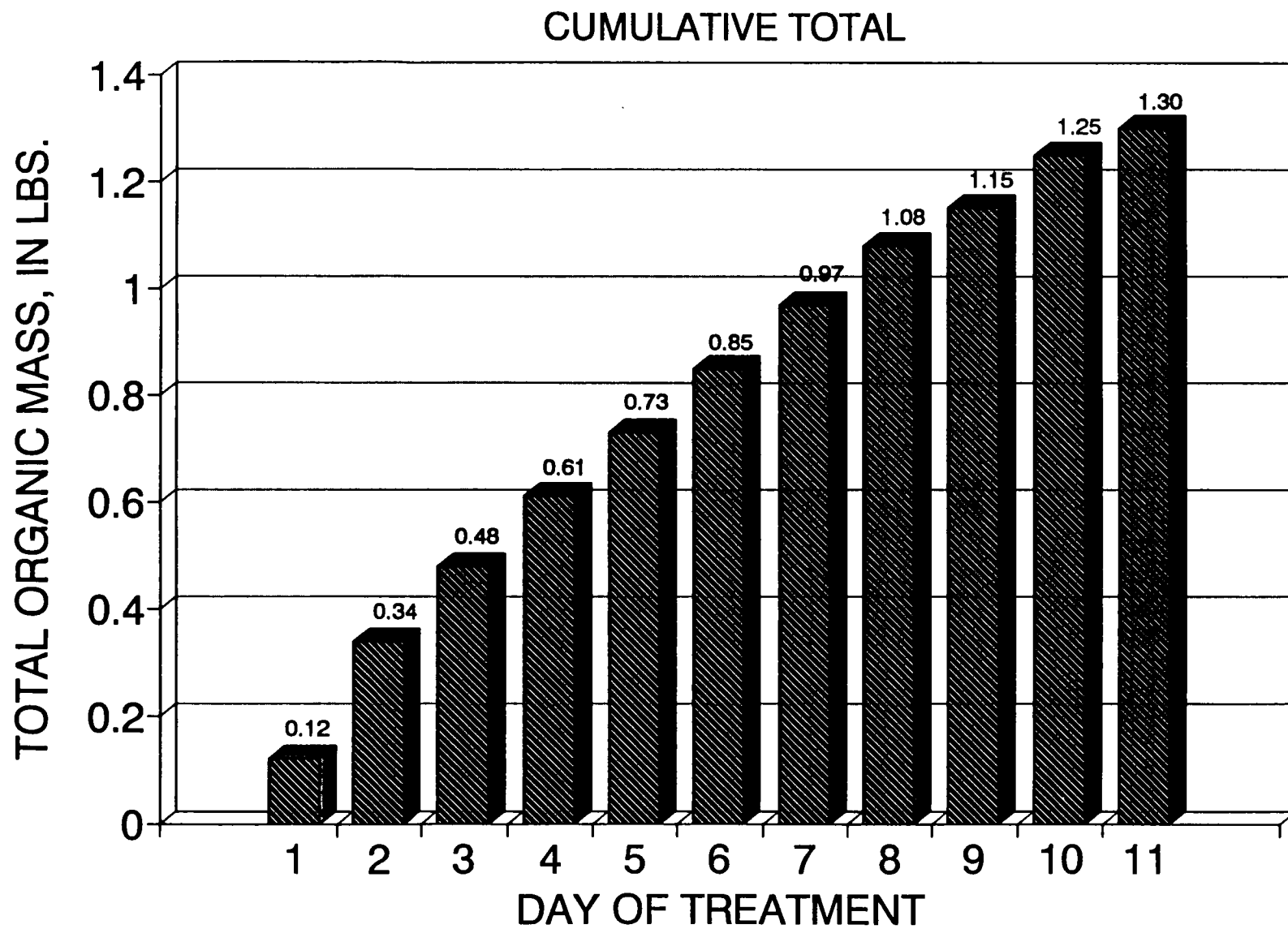
Laboratory results are located in Appendix G.

TABLE 4.3-13

Mass Flow Balance
Day 9 (5/18/91)

WELL	FLOW GPM	VC CONC (ug/L)	VC MASS (LB/DAY)	1,2-DCE CONC (ug/L)	1,2-DCE MASS (LB/DAY)	TCE CONC (ug/L)	TCE MASS (LB/DAY)	PCE CONC (ug/L)	PCE MASS (LB/DAY)
RW-1	0.22	2200	0.005816	3600	0.009517	310	0.000820	10	0.000026
RW-2	0.99	870	0.010350	960	0.011421	250	0.002974	11	0.000131
RW-3	0.08	710	0.000683	1300	0.001250	1300	0.001250	29	0.000028
RW-4	0.19	730	0.001667	1200	0.002740	360	0.000822	7	0.000016
RW-5	0.2	46	0.000111	360	0.000865	510	0.001226	13	0.000031
RW-6	0.06	720	0.000519	1800	0.001298	660	0.000476	19	0.000014
RW 1-6 (CALCULATED)	1.74	916	0.019145	1335	0.027091	362	0.007567	12	0.000246
(MEASURED)	1.7	760	0.015526	1100	0.022471	220	0.004494	19	0.000388
RW-7	0.82	<61	<0.00060	320	0.003153	540	0.005321	13	0.000128
RW-8	1.05	2	0.000025	250	0.003154	310	0.003911	9	0.000114
RW-9	1.15	<14	<0.00019	230	0.003178	160	0.002211	4	0.000055
RW-10	1	<25	<0.00030	280	0.003365	180	0.002163	6	0.000072
RW 7-10 (CALCULATED)	4.02	<23	<0.00112	266	0.012851	282	0.013607	8	0.000369
(MEASURED)	3.55	<50	<0.00213	450	0.019197	440	0.018770	<25	<0.001066
RW 1-10 (CALCULATED)	5.76	<293	<0.02026	577	0.039941	306	0.021174	9	0.000615
(MEASURED)	5.25	360	0.022712	990	0.062457	500	0.031544	<50	<0.003154

Lb/day calculated as follows: gal/min x conc. x 8.345 lb/gal x 1440 min/day
Calculated concentrations are obtained from the sum of the individual wells.

**FIGURE 4.3-9**

Total Organic Mass-Influent
Wells G&H /W.R. Grace Pilot Plant

TABLE 4.3-14

Grace Pilot Plant
Total Effluent - (V140)
VOC Concentrations

All results in ug/L

SAMPLE ID	V140V1FD	V140V2FS	V140V3FS	V140V4FS	V140V5FS	V140V6FS	V140V7FS	V140V8FS	V140V9FS	V140V10FS	V140V11FS
DAY OF RUN	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7	DAY 8	DAY 9	DAY 10	DAY 11
DATE SAMPLED	5/10/91	5/11/91	5/12/91	5/13/91	5/14/91	5/15/91	5/16/91	5/17/91	5/18/91	5/19/91	5/20/91
EPA METHOD	524.2	524.2	524.2	524.2	524.2	524.2	524.2	524.2	524.2	524.2	524.2
Vinyl chloride	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	2.4	0.5 U	0.5 U
Chloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1.5	0.5 U
Methylene chloride	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 B
1,1-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,2-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,2-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	12.1	0.9	0.5 U
Chloroform	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,1-Trichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Carbon tetrachloride	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromodichloromethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloropropane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,3-Dichloropropene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	8.2	0.6	0.3 J
Dibromochloromethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2-Trichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Benzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,3-Dichloropropene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromoform	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrachloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2,2-Tetrachloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Toluene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Ethylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Xylene, total	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

See Table 4.3-28 for an explanation of the data qualifiers.

Laboratory results are located in Appendix G.

treatment plant. A comparison of the influent and the effluent shows removal efficiencies in excess of 99 percent of the volatile organics, with complete removal (all compounds below the detection limit of 0.5 µg/L) of volatile organics by the treatment system on Days 1 through 8. Positively identified compounds on Day 9 are accounted for in the summary of Table 4.3-18 and attributable to the lower UV dosages on that day as part of the optimization process.

4.3.3.4 Optimization Trials Data

An optimization study was conducted during Days 6 through 9 to evaluate the change in volatile organic removal efficiency when certain independent variable conditions are altered. Independent variables were UV dosage (adjusted by varying the flowrate and number of lamps) and hydrogen peroxide dosage. The results of this study were compiled into tabular form and presented in Tables 4.3-15 through 4.3-19. Table 4.3-15 presents data comparing influent volatile organic concentrations with effluent volatile organic concentrations under various operating conditions. Samples are identified alphanumerically: the first two numbers correspond with the date (in May 1991) of the trial; the next letter is designated A for influent, C for the effluent after passing the first UV lamp, and D for final effluent after two UV lamps [an available site at position "B" for an additional UV lamp was not utilized (see Figure 4.3-10 for sampling port diagram)]; and the last number indicates the specific optimization trial on that particular date. Tables 4.3-16 through 4.3-19 show system removal efficiencies for the four volatile compounds which were the main contaminants in the ground water and reflect information presented in Table 4.3-19.

During the various trials, data was collected in order to make conclusions regarding hydrogen peroxide concentrations and degradation; removal efficiencies based upon influent hydrogen peroxide concentrations; and removal efficiencies based upon UV dosage (measured in kilowatt-hours (KWhr) per 1,000 gallons). The bar charts in Appendix P present the operating conditions during each trial and percent removal of the four major organic chemicals found in the ground water after passing one 6-KW UV lamp and after passing two 6-KW UV lamps. These figures show greater than 95 percent removal efficiencies for all chemicals during all trials after passing the first UV lamp and greater than 99 percent of all compounds efficiency after two lamps. The removal efficiency across the second lamp is uncertain due to nearly all analytical results being below detection levels or qualified as being uncertain.

Figures 4.3-11 through 4.3-13 present the measured change in hydrogen peroxide concentration after the first UV lamp, after the second UV lamp, and after both lamps combined for each optimization trial. These figures indicate a direct correlation between UV dose (KWhr/1,000 gal) and hydrogen peroxide degradation to hydroxyl radicals, which promote the destruction and removal of volatile organics.

TABLE 4.3-15
Grace Pilot Plant
Optimization Trials Data

All results in ug/L

SAMPLE ID #	15A1	15C1	16A1	16C1	16D1	16C2	16D2	16C3	16D3
INFLUENT FLOW, GPM		5		5	5	5	5	10	10
POWER, IN KW		6		6	12	6	12	6	12
H2O2 IN, IN PPM		30		90	90	40	40	40	40
H2O2 OUT, IN PPM		20		75	60	30	20	33	25
COMPOUND									
chloroethane	59U	0.9	43U	0.5U	0.5U	0.5U	0.5U	1	0.5U
vinyl chloride	390D	0.5U	280	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U
methylene chloride (a)	178DJ	0.5U	5J	0.5BJ	0.5U	0.8B	0.5U	0.2BJ	0.5U
acetone (a)	2008D	0.5U	43U	9	9	0.5U	13	12	11B
1,2-dichloroethene, total	660D	0.5U	630	0.5U	0.5U	0.5U	0.5U	1	0.5U
trichloroethane	29U	0.5U	21U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U
trichloroethene	390D	0.8B	330	0.2BJ	0.5U	0.6B	0.5U	2B	0.5U
tetrachloroethene	9DJ	0.5U	10J	0.5U	0.2J	0.5U	0.5U	0.2J	0.5U
toluene	29U	0.5U	21U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U
xylene, total	29U	0.5U	21U	0.5U	0.5U	0.5U	0.5U	0.4J	0.5U

SAMPLE ID #	17A1	17C1	17D1	17C2	17D2	17C3	17D3	18A1	18C1	18D1
INFLUENT FLOW, GPM		20	20	20	20	10	10		30	30
POWER, IN KW		6	12	6	12	6	12		6	12
H2O2 IN, IN PPM		50	50	20	20	90			50	50
H2O2 OUT, IN PPM		45	40	15	15	80			48	46
COMPOUND									*	*
chloroethane	33U	0.7	0.4J	2	2	0.5U	0.5U	10U	1	0.8
vinyl chloride	250	0.5U	0.5U	8	0.4J	0.5U	0.5U	240	0.3J	0.5U
methylene chloride (a)	4J	0.3BJ	0.2BJ	0.5BJ	0.6B	0.5B	0.3BJ	3J	1B	0.5U
acetone (a)	6J	10	5U	12	5U	13	5U	33U	0.5U	5U
1,2-dichloroethene, total	560	0.3J	0.5U	25	2	0.5U	0.5U	550	2	0.5U
trichloroethane	17U	0.4J	0.5U	0.3J	0.3J	0.5U	0.5U	17U	0.5U	0.5U
trichloroethene	320	0.7	0.5U	25	3	0.5U	0.5U	370	3	0.5U
tetrachloroethene	9J	0.5U	0.5U	0.9	0.5U	0.5U	0.5U	11J	0.5J	0.5U
toluene	4J	0.2J	0.2J	0.4J	0.2J	0.2J	0.2J	8J	0.2J	0.5U
xylene, total	17U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	17U	0.5U	0.5U

NOTES: 1. (a) indicates typical laboratory contaminants (acetone and methylene chloride) are not considered positively identified compounds for the purpose of determining efficiencies.

2. Estimated values (J) are considered positively identified for the purpose of determining efficiencies.

3. * : Sample 18C1 also contained 5J 2-butanone; sample 18D1 also contained 0.3J chloromethane.

4. See Table 4.3-28 for an explanation of the data qualifiers.

Laboratory results are located in Appendix G.

TABLE 4.3-16

Grace Pilot Plant
Removal Efficiency For Vinyl Chloride

Trial Run #	Power (KW) (1.)	Inlet H2O2 Conc (mg/L)	Outlet H2O2 Conc (mg/L)	Water Flowrate (GPM)	UV DOSE kWhr/1000 Gals	VC Influent Conc (ug/L)	VC Effluent Conc (ug/L)	Removal Efficiency (%)
15-AC	6	30	20	5	20	390 D	< 0.5 U	> 99.87
16-AC1	6	90	75	5	20	280	< 0.5 U	> 99.82
16-AC2	6	40	30	5	20	280	< 0.5 U	> 99.82
16-AC3	6	40	33	10	10	280	< 0.5 U	> 99.82
17-AC1	6	50	45	20	5	250	< 0.5 U	> 99.80
17-AC2	6	20	15	20	5	250	8	96.80
17-AC3	6	90	85	10	10	250	< 0.5 U	> 99.80
18-AC	6	50	48	30	3.3	240	0.3 J	99.88
16-CD1	6	75	60	5	20	< 0.5 U	< 0.5 U	0.00
16-CD2	6	30	20	5	20	< 0.5 U	< 0.5 U	0.00
16-CD3	6	33	25	10	10	< 0.5 U	< 0.5 U	0.00
17-CD1	6	45	40	20	5	< 0.5 U	< 0.5 U	0.00
17-CD2	6	15	15	20	5	8	0.4 J	95.00
17-CD3	6	85	80	10	10	< 0.5 U	< 0.5 U	0.00
18-CD	6	48	46	30	3.3	0.3 J	< 0.5 U	NA
16-AD1	12	90	60	5	40	280	< 0.5 U	> 99.82
16-AD2	12	40	20	5	40	280	< 0.5 U	> 99.82
16-AD3	12	40	25	10	20	280	< 0.5 U	> 99.82
17-AD1	12	50	40	20	10	250	< 0.5 U	> 99.80
17-AD2	12	20	15	20	10	250	0.4 J	99.84
17-AD3	12	90	80	10	20	250	< 0.5 U	> 99.80
18-AD	12	50	46	30	6.6	240	< 0.5 U	> 99.79

- NOTES:
1. Each lamp's Power is 6KW, ie: Across 1 lamp is 6KW and across 2 lamps is 12KW.
 2. NA indicates not applicable since efficiency was calculated to be less than zero.
 3. See Table 4.3-28 for an explanation of the data qualifiers.
 4. Estimated values (J) are considered positively identified values for the purpose of determining efficiencies.
 5. Removal efficiencies are calculated using the detection limits when compounds are not detected.
- Laboratory results are located in Appendix G.

TABLE 4.3-17

Grace Pilot Plant
Removal Efficiency for Total 1,2-Dichloroethene

Trial Run #	Power (KW)(1.)	Inlet H2O2 Conc (mg/L)	Outlet H2O2 Conc (mg/L)	Water Flowrate (GPM)	UV DOSE kWhr/1000 Gals	1,2-DCE Influent Conc (ug/L)	1,2-DCE Effluent Conc (ug/L)	Removal Efficiency (%)
15-AC	6	30	20	5	20	660 D	< 0.5 U	> 99.92
16-AC1	6	90	75	5	20	630	< 0.5 U	> 99.92
16-AC2	6	40	30	5	20	630	< 0.5 U	> 99.92
16-AC3	6	40	33	10	10	630	1	99.84
17-AC1	6	50	45	20	5	560	0.3 J	99.95
17-AC2	6	20	15	20	5	560	25	95.54
17-AC3	6	90	85	10	10	560	< 0.5 U	> 99.91
18-AC	6	50	48	30	3.3	550	2	99.64
16-CD1	6	75	60	5	20	< 0.5 U	< 0.50 U	0.00
16-CD2	6	30	20	5	20	< 0.5 U	< 0.50 U	0.00
16-CD3	6	33	25	10	10	1	< 0.50 U	> 50.00
17-CD1	6	45	40	20	5	0.3 J	< 0.50 U	NA
17-CD2	6	15	15	20	5	25	2	92.00
17-CD3	6	85	80	10	10	< 0.5 U	< 0.50 U	0.00
18-CD	6	48	46	30	3.3	2	< 0.50 U	> 75.00
16-AD1	12	90	60	5	40	630	< 0.50 U	> 99.92
16-AD2	12	40	20	5	40	630	< 0.50 U	> 99.92
16-AD3	12	40	25	10	20	630	< 0.50 U	> 99.92
17-AD1	12	50	40	20	10	560	< 0.50 U	> 99.91
17-AD2	12	20	15	20	10	560	2	99.64
17-AD3	12	90	80	10	20	560	< 0.50 U	> 99.91
18-AD	12	50	46	30	6.6	550	< 0.50 U	> 99.91

- NOTES: 1. Each lamp's Power is 6KW, ie: Across 1 lamp is 6KW and across 2 lamps is 12KW.
 2. NA indicates not applicable since efficiency was calculated to be less than zero.
 3. See Table 4.3-28 for an explanation of the data qualifiers.
 4. Estimated values (J) are considered positively identified values for the purpose of determining efficiencies.
 5. Removal efficiencies are calculated using the detection limits when compounds are not detected.
 Laboratory results are located in Appendix G.

TABLE 4.3-18

Grace Pilot Plant
Removal Efficiency For Trichloroethene

Trial Run #	Power (KW)(1.)	Inlet H2O2 Conc (mg/L)	Outlet H2O2 Conc (mg/L)	Water Flowrate (GPM)	UV DOSE kWhr/1000 Gals	TCE Influent Conc (ug/L)	TCE Effluent Conc (ug/L)	Removal Efficiency (%)
15-AC	6	30	20	5	20	390 D	0.8 B	99.79
16-AC1	6	90	75	5	20	330	0.2 BJ	99.94
16-AC2	6	40	30	5	20	330	0.6 B	99.82
16-AC3	6	40	33	10	10	330	2 B	99.39
17-AC1	6	50	45	20	5	320	0.7	99.78
17-AC2	6	20	15	20	5	320	25	92.19
17-AC3	6	90	85	10	10	320	< 0.5 U	> 99.84
18-AC	6	50	48	30	3.3	370	3	99.19
16-CD1	6	75	60	5	20	< 0.2 BJ	< 0.5 U	NA
16-CD2	6	30	20	5	20	0.6 B	< 0.5 U	> 16.67
16-CD3	6	33	25	10	10	2 B	< 0.5 U	> 75.00
17-CD1	6	45	40	20	5	0.7	< 0.5 U	> 28.57
17-CD2	6	15	15	20	5	25	3	88.00
17-CD3	6	85	80	10	10	< 0.5 U	< 0.5 U	0.00
18-CD	6	48	46	30	3.3	3	< 0.5 U	> 83.33
16-AD1	12	90	60	5	40	330	< 0.5 U	> 99.85
16-AD2	12	40	20	5	40	330	< 0.5 U	> 99.85
16-AD3	12	40	25	10	20	330	< 0.5 U	> 99.85
17-AD1	12	50	40	20	10	320	< 0.5 U	> 99.84
17-AD2	12	20	15	20	10	320	3	99.06
17-AD3	12	90	80	10	20	320	< 0.5 U	> 99.84
18-AD	12	50	46	30	6.6	370	< 0.5 U	> 99.86

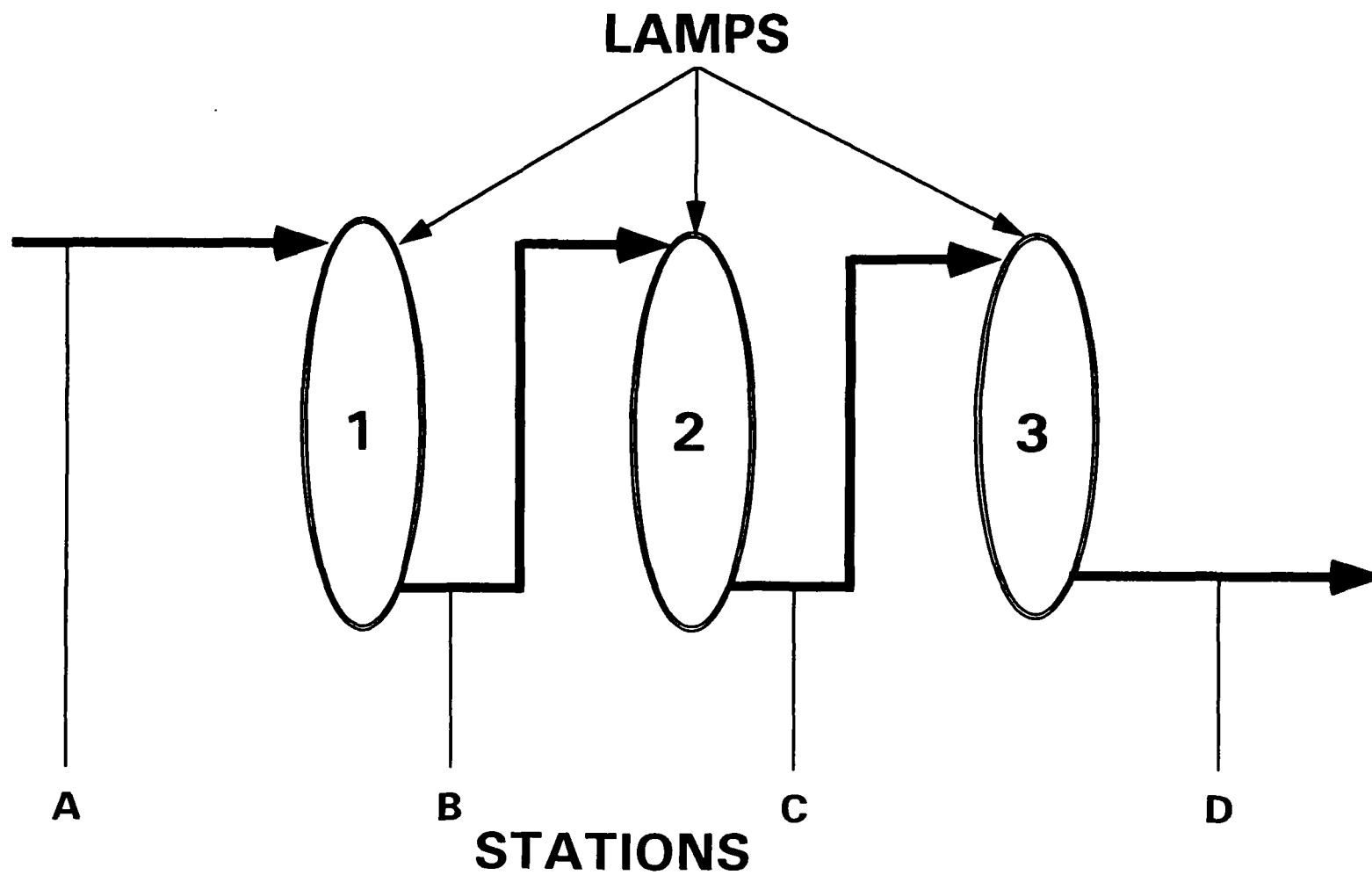
- NOTES:
1. Each lamp's Power is 6KW, ie: Across 1 lamp is 6KW and across 2 lamps is 12KW.
 2. NA indicates not applicable since efficiency was calculated to be less than zero.
 3. See Table 4.3-28 for a definition of data qualifiers.
 4. Estimated values (J) are considered positively identified values for the purpose of determining efficiencies.
 5. Removal efficiencies are calculated using the detection limits when compounds are not detected.
- Laboratory results are located in Appendix G.

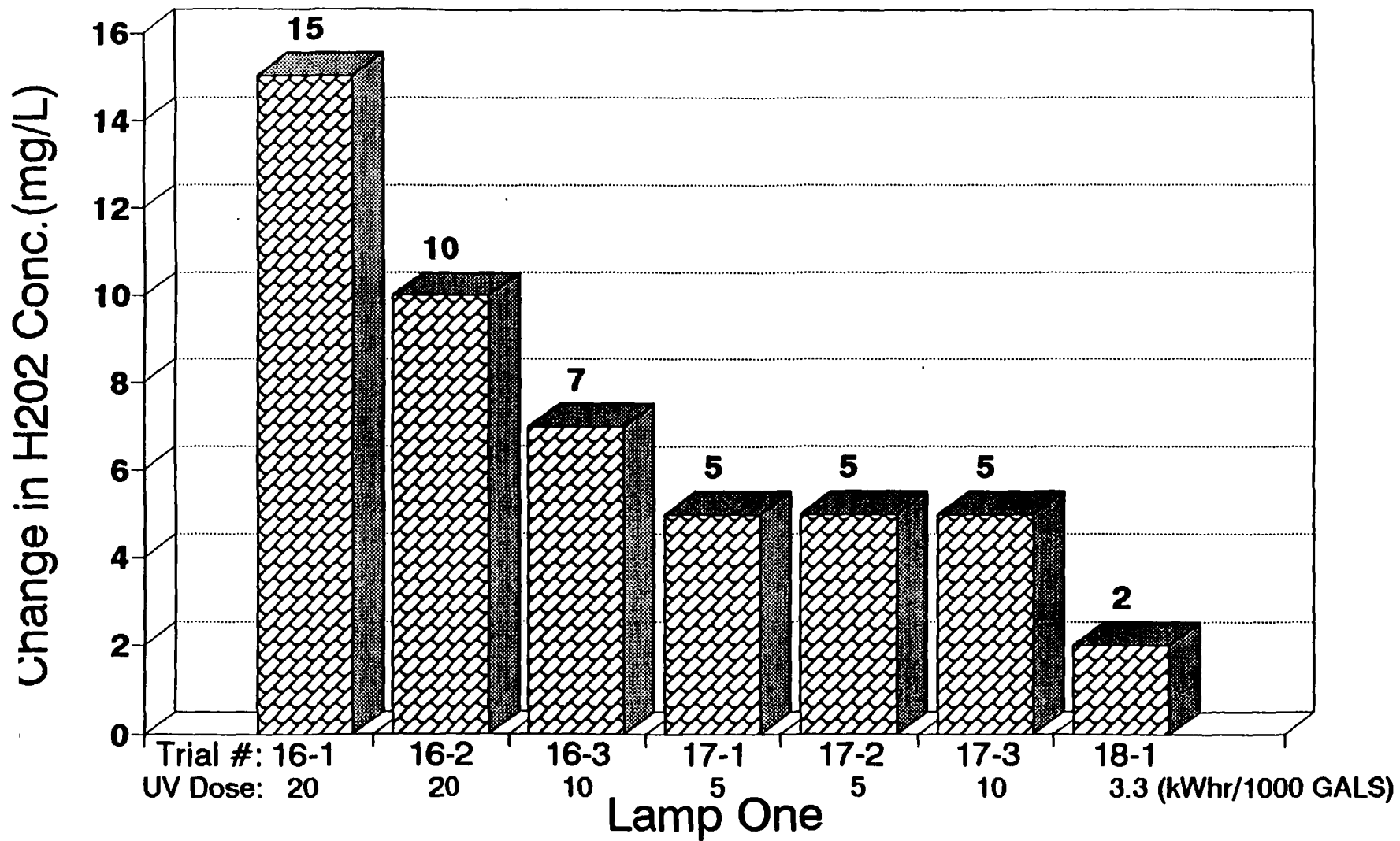
TABLE 4.3-19

Grace Pilot Plant
Removal Efficiency

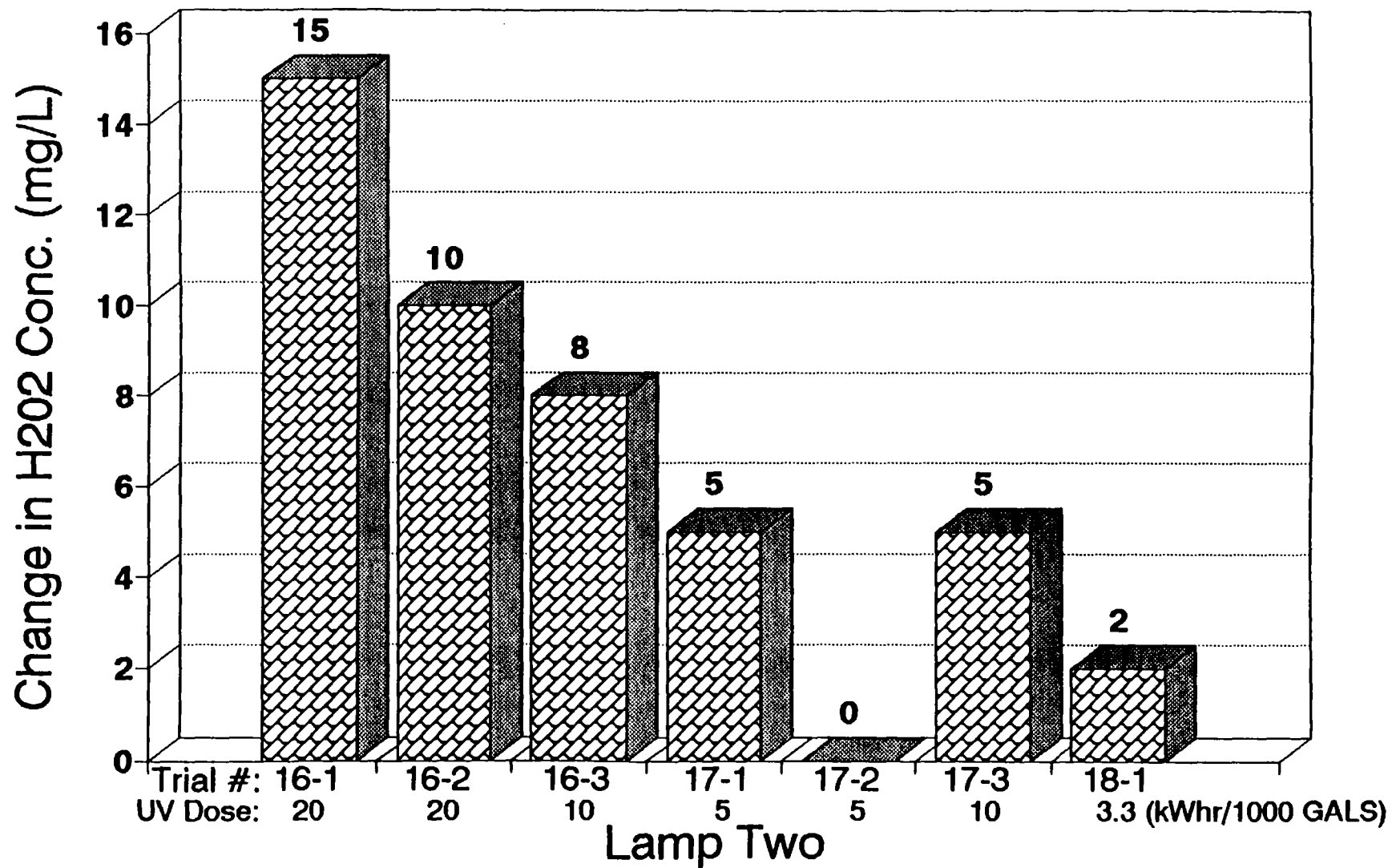
Trial Run #	Power (KW)(1.)	Inlet H2O2 Conc (mg/L)	Outlet H2O2 Conc (mg/L)	Water Flowrate (GPM)	UV DOSE kWhr/1000 Gals	PCE Influent Conc (ug/L)	PCE Effluent Conc (ug/L)	Removal Efficiency (%)
15-AC	6	30	20	5	20	9 DJ	< 0.5 U	> 94.44
16-AC1	6	90	75	5	20	10 J	< 0.5 U	> 95.00
16-AC2	6	40	30	5	20	10 J	< 0.5 U	> 95.00
16-AC3	6	40	33	10	10	10 J	< 0.5 U	> 95.00
17-AC1	6	50	45	20	5	9 J	< 0.5 U	> 94.44
17-AC2	6	20	15	20	5	9 J	0.9	90.00
17-AC3	6	90	85	10	10	9 J	0.5 J	94.44
18-AC	6	50	48	30	3.3	11 J	0.5 J	95.45
16-CD1	6	75	60	5	20	< 0.5 U	0.2 J	60.00
16-CD2	6	30	20	5	20	< 0.5 U	< 0.5 U	0.00
16-CD3	6	33	25	10	10	< 0.5 U	< 0.5 U	0.00
17-CD1	6	45	40	20	5	< 0.5 U	< 0.5 U	0.00
17-CD2	6	15	15	20	5	0.9	< 0.5 U	> 44.44
17-CD3	6	85	80	10	10	0.5 J	< 0.5 U	0.00
18-CD	6	48	46	30	3.3	0.5 J	< 0.5 U	0.00
16-AD1	12	90	60	5	40	10 J	0.2 J	98.00
16-AD2	12	40	20	5	40	10 J	< 0.5 U	> 95.00
16-AD3	12	40	25	10	20	10 J	< 0.5 U	> 95.00
17-AD1	12	50	40	20	10	9 J	< 0.5 U	> 94.44
17-AD2	12	20	15	20	10	9 J	< 0.5 U	> 94.44
17-AD3	12	90	80	10	20	9 J	< 0.5 U	> 94.44
18-AD	12	50	46	30	6.6	11 J	< 0.5 U	> 95.45

- NOTES: 1. Each lamp's Power is 6KW, ie: Across 1 lamp is 6KW and across 2 lamps is 12KW.
 2. NA indicates not applicable since efficiency was calculated to be less than zero.
 3. See Table 4.3-28 for a definition of data qualifiers.
 4. Estimated values (J) are considered positively identified values for the purpose of determining efficiencies.
 5. Removal efficiencies are calculated using the detection limits when the compound is not detected.
 Laboratory results are located in Appendix G.

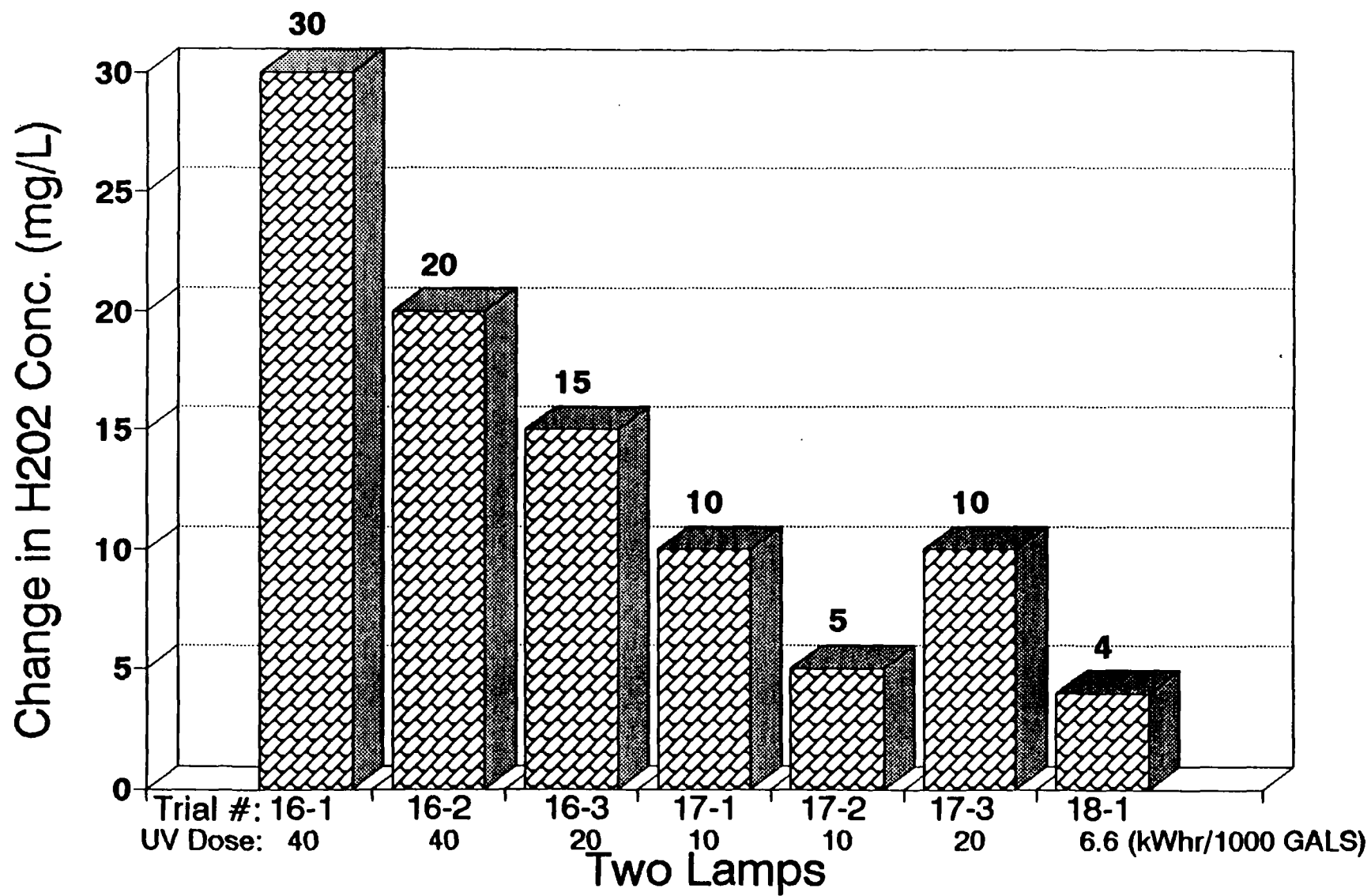
**FIGURE 4.3-10**

**FIGURE 4.3-11****DRAFT**

Change in H₂O₂ Concentration after Lamp 1
Wells G&H/W.R. Grace Pilot Plant

**FIGURE 4.3-12**

Change in H₂O₂ Concentration after Lamp 2
Wells G&H/W.R. Grace Pilot Plant

**FIGURE 4.3-13**

Figures 4.3-14 through 4.3-17 present removal efficiencies of trichloroethene, tetrachloroethene, 1,2-dichloroethene and vinyl chloride at various influent hydrogen peroxide concentrations. The data qualifiers are explained in Table 4.3-2. A review of these graphs shows virtually complete removal of all volatile organics at all concentrations of 30 mg/L and above. At 20 mg/L, the effluent contained positive amounts of all four chemicals at levels below the FWACAL.

Figures 4.3-18 through 4.3-21 compare UV dosage efficiencies for trichloroethene, tetrachloroethene, 1,2-dichloroethene and vinyl chloride over the range of 3.3 to 20 KW hr/1,000 gal. Over this range, each UV dose was sufficient to remove over 99 percent of all four chemicals.

Removal efficiencies during all the trials exceeded 99.8 percent (due to low initial concentrations of tetrachloroethene, removal efficiencies could only be estimated at greater than 94 percent) for these four compounds after passing both six-kilowatt lamps with the singular exception of the second trial on May 17, 1991, when hydrogen peroxide influent concentration was the lowest. In general, greater than 99 percent of these organics were removed after the first lamp, indicating sufficient UV dosage with only one six-kilowatt lamp. Of the conditions tested, only hydrogen peroxide concentrations below 30 mg/L were associated with concentrations above detection levels of 0.5 µg/L.

4.3.3.5 Sludge Samples

Sludge samples were taken and analyzed in accordance with the work plan for metals, VOC and radionuclides. The total mass of material which precipitated onto the 5 micron bag filter was significantly less than anticipated and was estimated at less than 100 grams. The majority of this sludge material was delivered to the laboratory as a sample in order to determine the proper disposal of this material, as described in the Work Plan.

Table 4.3-20 presents the results for metals and compares the data to the Resource Conservation and Recovery Act (RCRA) regulatory disposal criteria for solid waste. The sludge was acceptable for all metals except chromium (107 mg/Kg compared to the regulatory limit of 100 mg/Kg). However, based upon the quantity generated and the low levels of regulated metals, no Toxicity Characteristic Leachate Procedure (TCLP) analysis was conducted or is planned. The remaining sludge is stored safely on the Grace property and will be combined with the sludge generated from the final treatment system. When an appropriate quantity of sludge has been accumulated, samples will again be analyzed in order to determine proper disposal requirements.

Table 4.3-21 presents the data obtained from the laboratory for the analysis of volatiles in the sludge sample. The laboratory reported a moisture content of 36.4 percent by weight sludge.

4-110

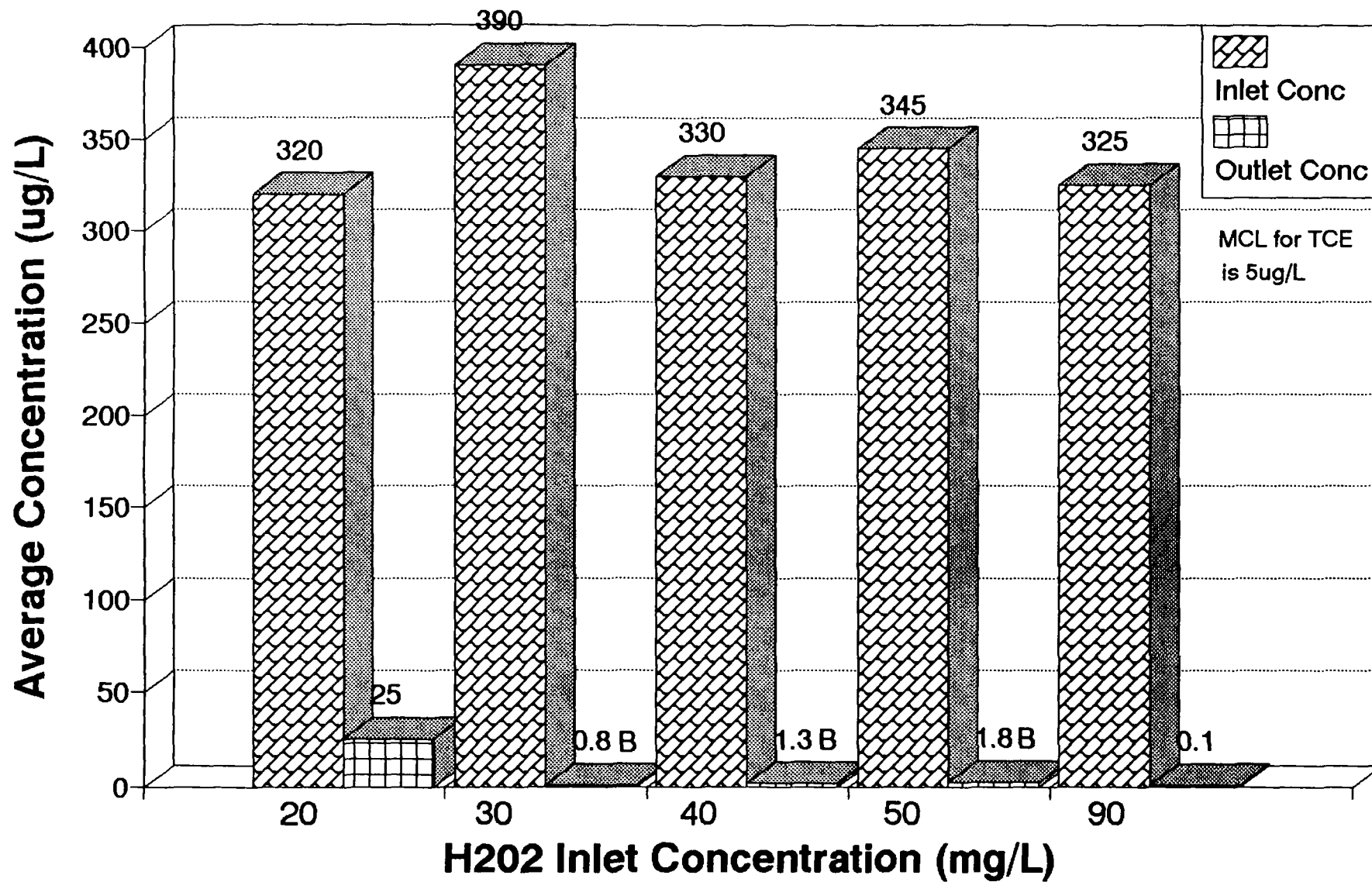
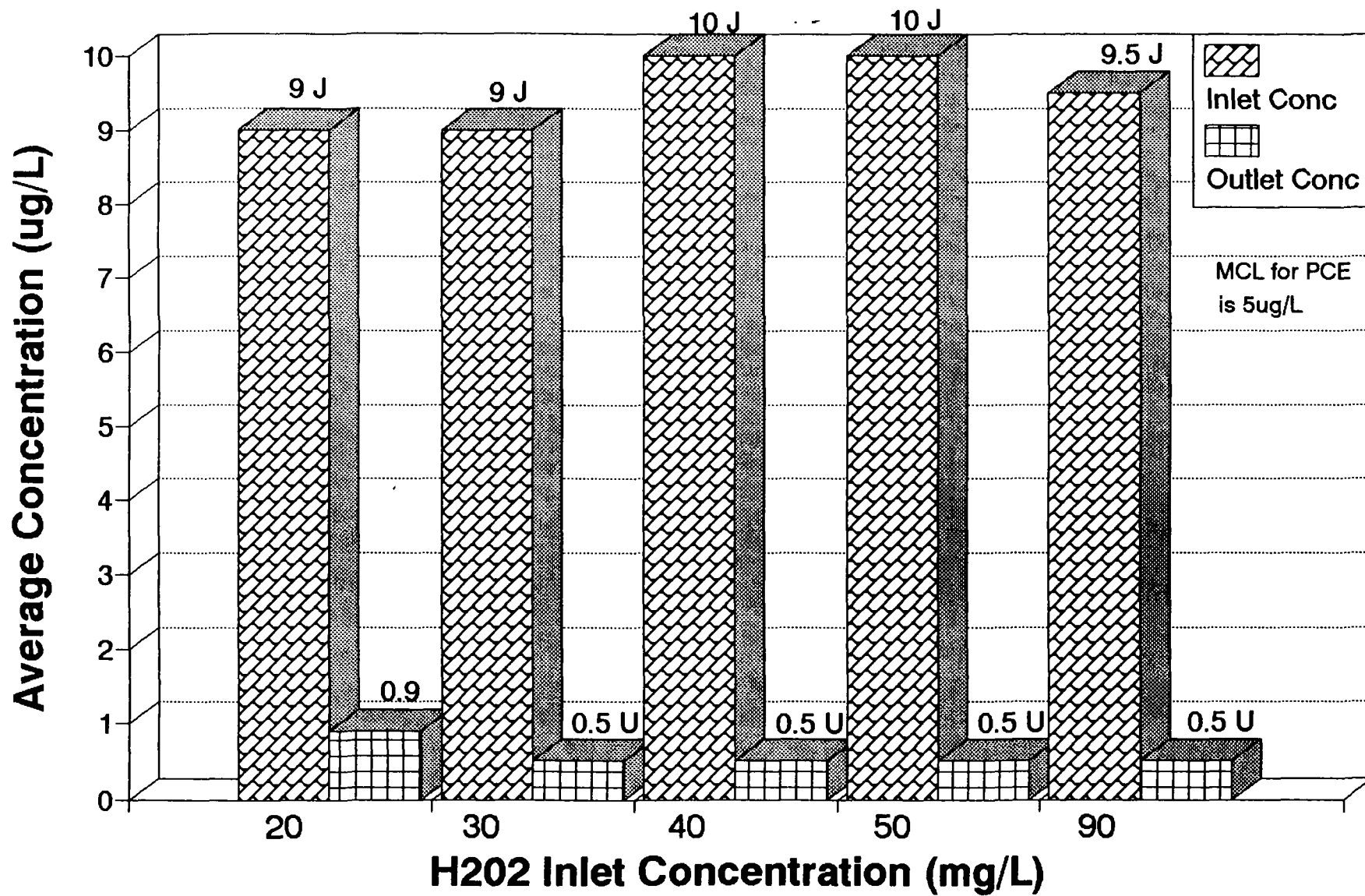


FIGURE 4.3-14

H2O2 Inlet Concentration Efficiency for Trichloroethene
Wells G&H/W.R. Grace Pilot Plant

DRAFT

**FIGURE 4.3-15**

4-112

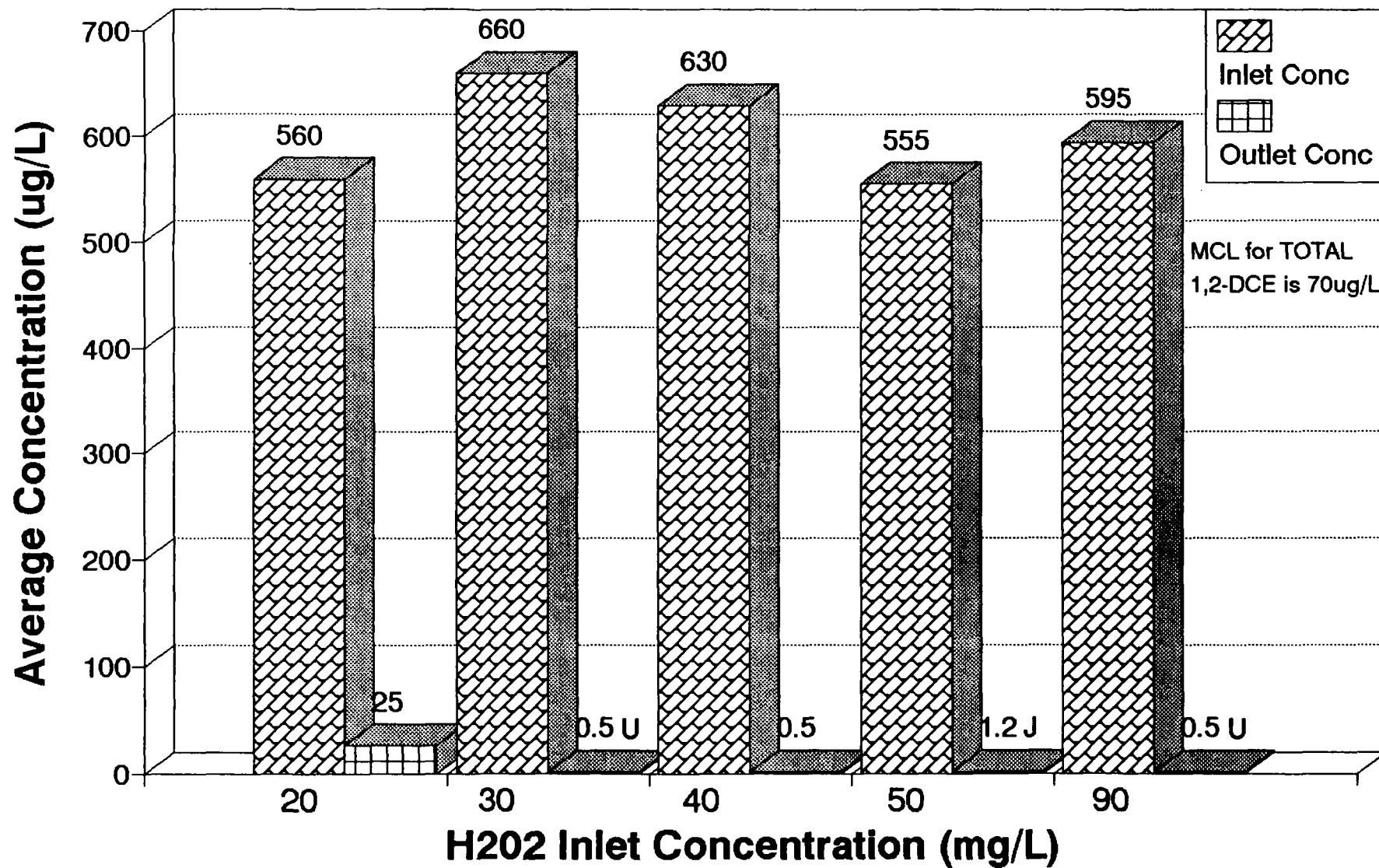
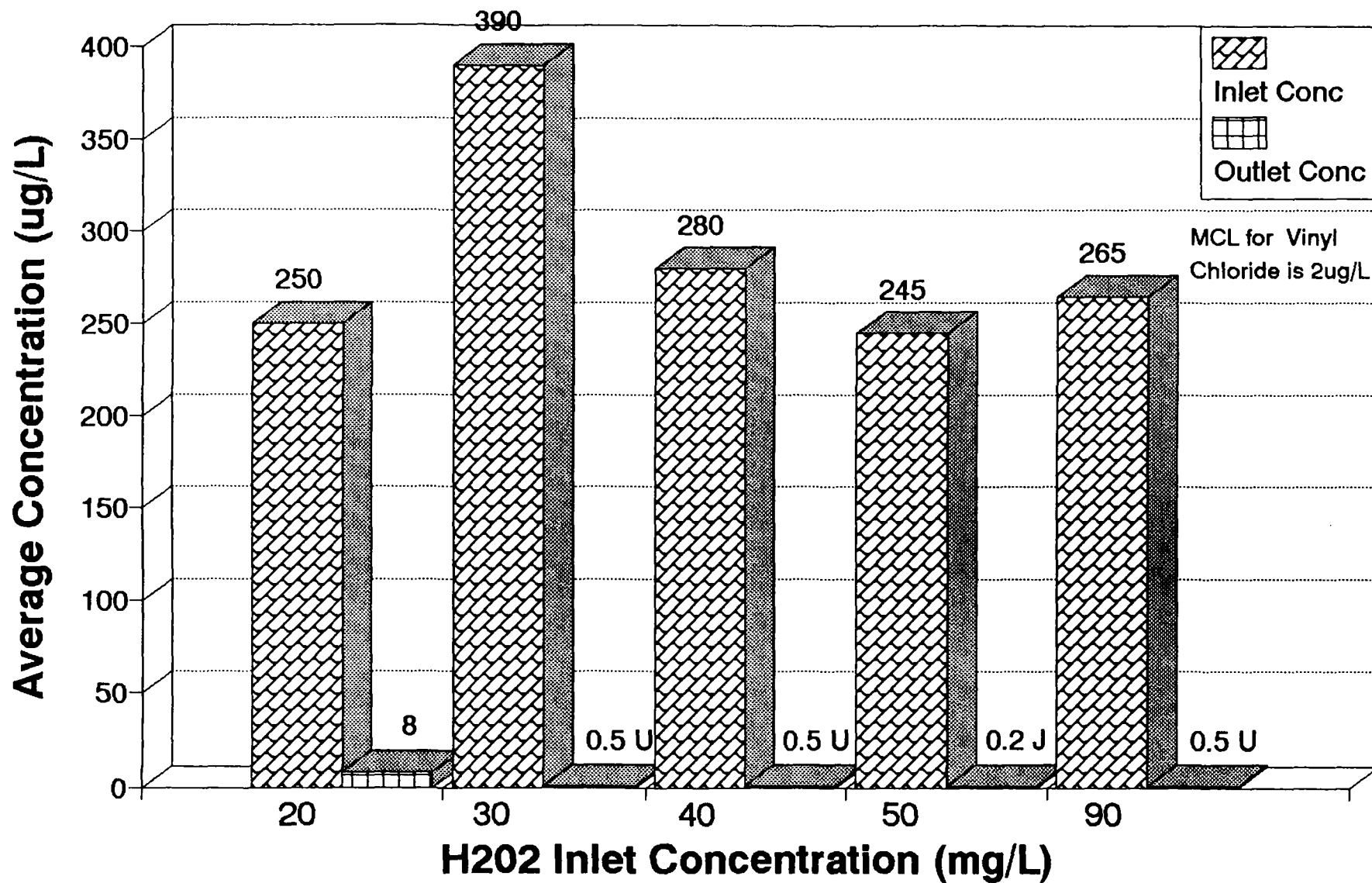
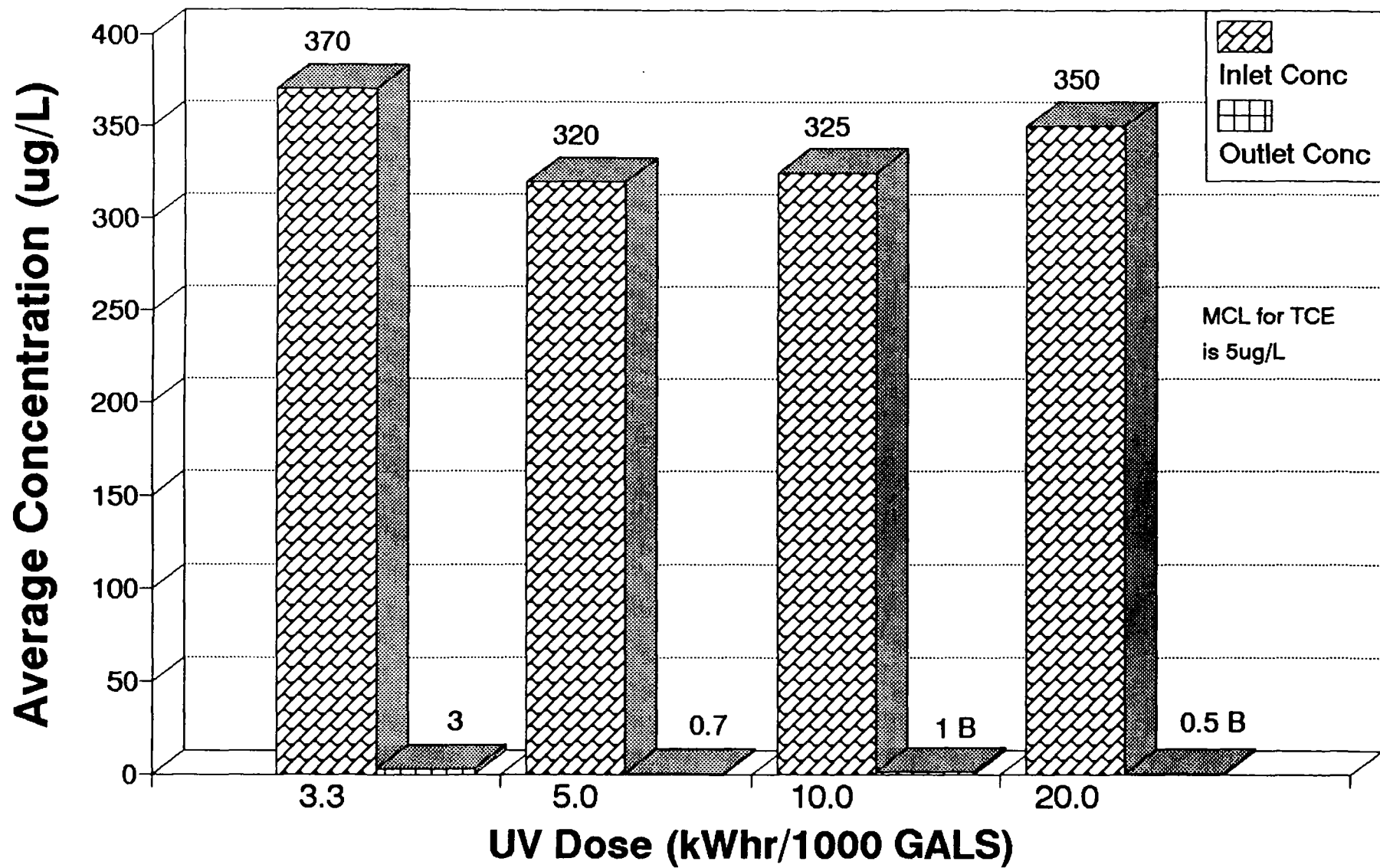


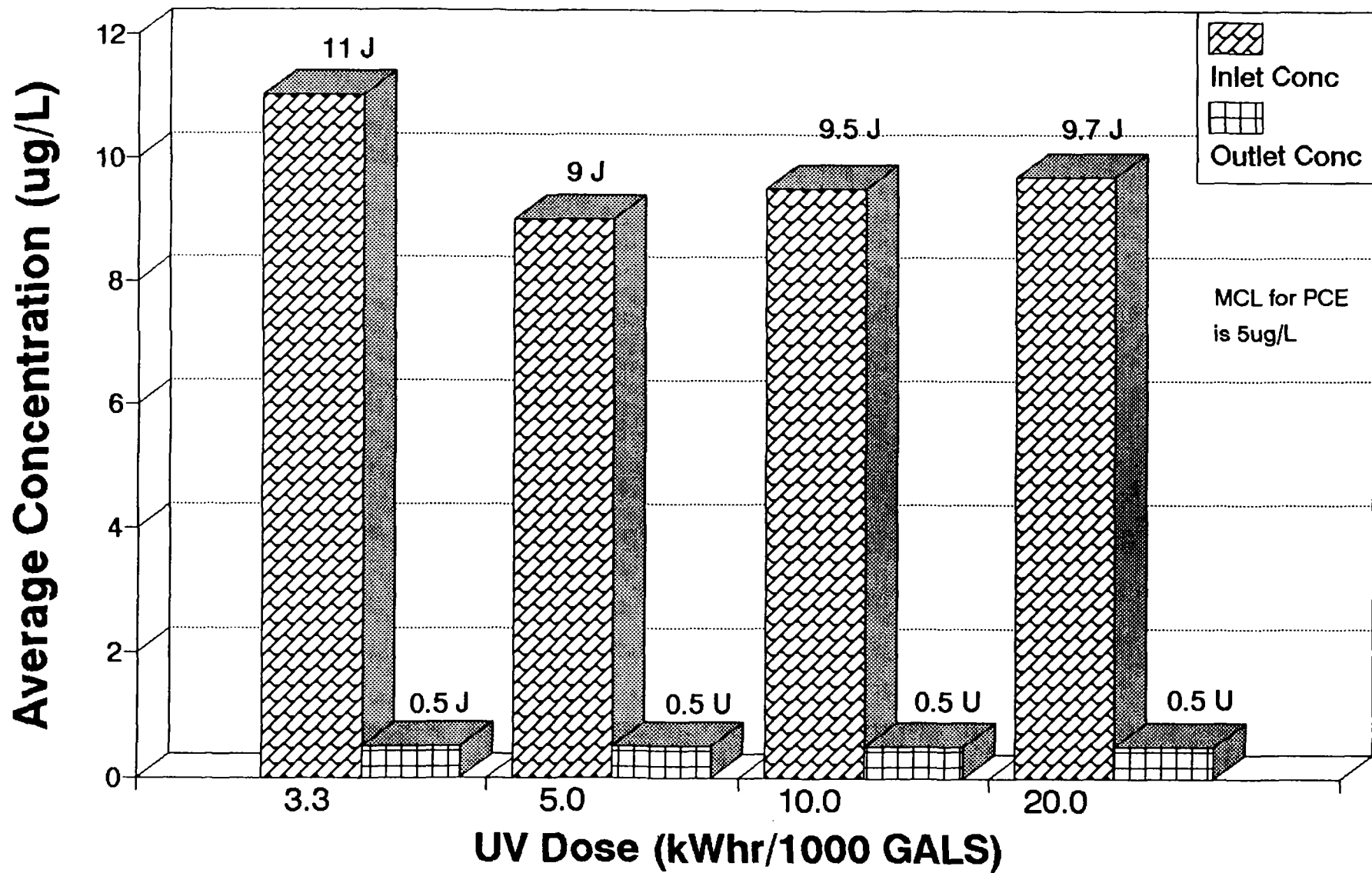
FIGURE 4.3-16

DRAFT

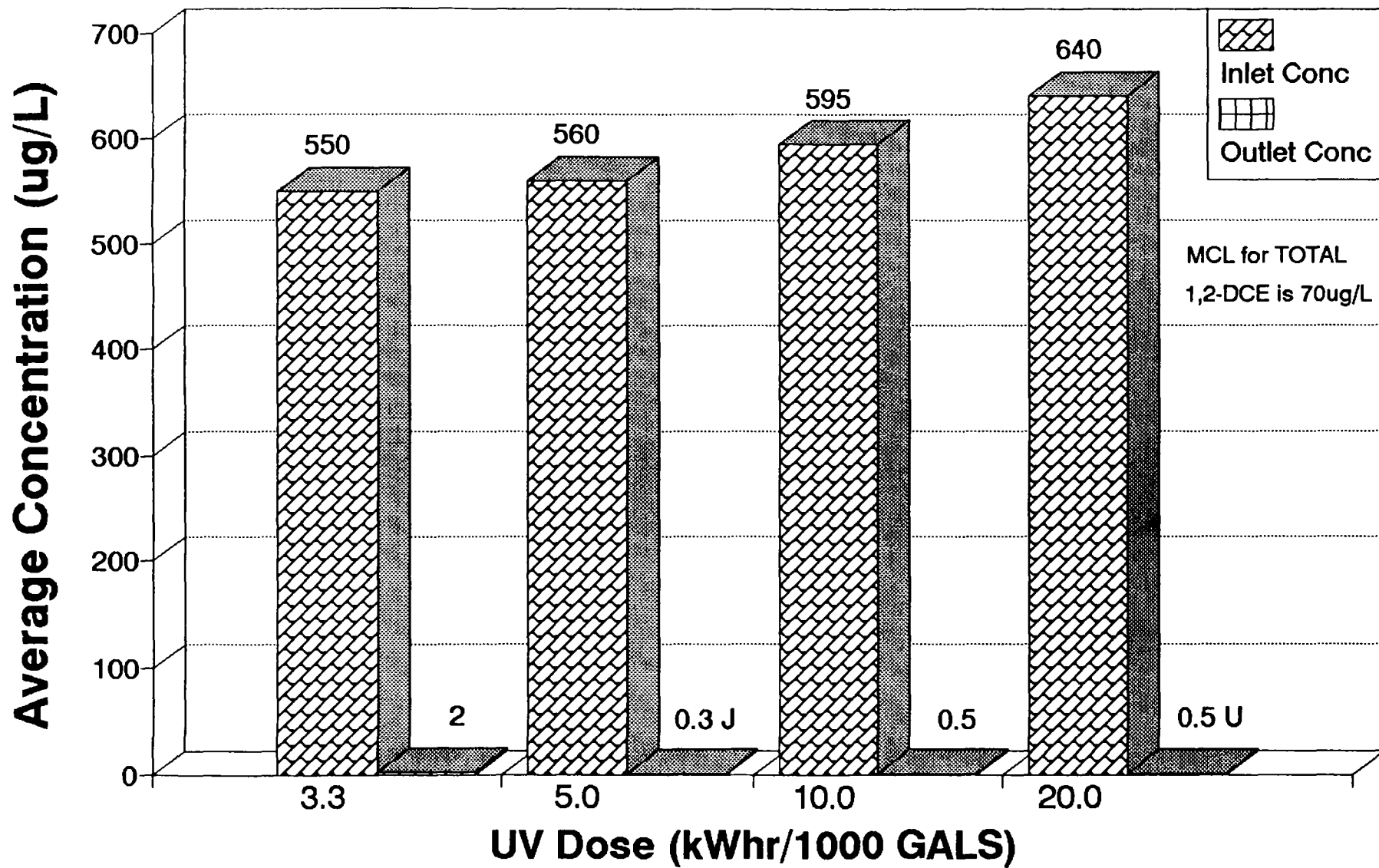
H₂O₂ Inlet Concentration Efficiency for Total 1,2-Dichloroethene
Wells G&H/W.R. Grace Pilot Plant

**FIGURE 4.3-17**

**FIGURE 4.3-18**

**FIGURE 4.3-19**

Comparison of UV Dose Efficiency for Tetrachloroethene
Wells G&H/W.R. Grace Pilot Plant

**FIGURE 4.3-20**

DRAFT

Comparison of UV Dose Efficiency for Trichloroethene
Wells G&H/W.R. Grace Pilot Plant

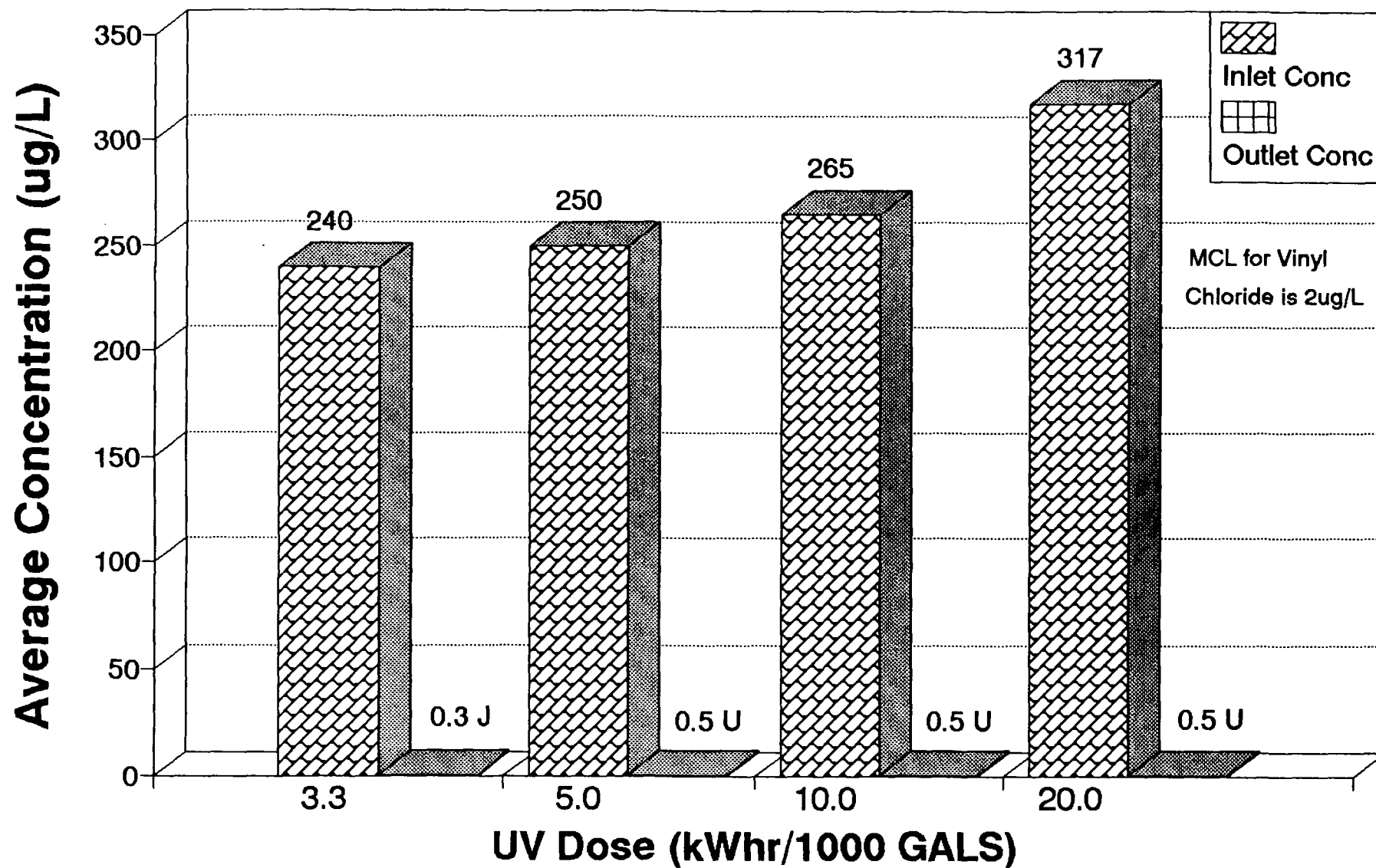
**FIGURE 4.3-21****DRAFT**Comparison of UV Dose Efficiency for Vinyl Chloride
Wells G&H/W.R. Grace Pilot Plant

TABLE 4.3-20

Grace Pilot Plant
Sludge Sample
Metals Concentration

All results in mg/Kg

SAMPLE ID DATE SAMPLED	SLUDGE CU 5/23/91	RCRA LIMIT
Aluminum	10700	*
Antimony	0.66 B	*
Arsenic	44.4	100
Barium	125	2000
Beryllium	11.5	*
Cadmium	4.4	20
Calcium	7750	*
Chromium	107	100
Cobalt	14.3 B	*
Copper	211	*
Iron	87400	*
Lead	34.6	100
Magnesium	4540	*
Manganese	890	*
Mercury	0.27 U	4
Nickel	44.5	*
Potassium	1700 B	*
Selenium	0.27 U	20
Silver	7.7	100
Sodium	403 B	*
Thallium	0.38 U	*
Vanadium	41.2	*
Zinc	462	*

* No disposal regulatory level has been established.

See Table 4.3-28 for an explanation of the data qualifiers.

Laboratory results are located in Appendix G.

TABLE 4.3-21

Grace Pilot Plant
Sludge Sample
VOC Concentrations

All results in ug/L

SAMPLE ID DATE SAMPLED	SLUDGE CU 5/23/91	RCRA LIMIT
Chloromethane	10 U	*
Bromomethane	10 U	*
Vinyl chloride	10 U	*
Chloroethane	10 U	*
Methylene chloride	5 U	*
Acetone	25	*
Carbon disulfide	5 U	*
1,1-Dichloroethene	5 U	*
1,1-Dichloroethane	5 U	*
1,2-Dichloroethene, total	3 J	*
Chloroform	5 U	*
1,2-Dichloroethane	5 U	*
2-Butanone	10 U	*
1,1,1-Trichloroethane	5 U	*
Carbon tetrachloride	5 U	*
Vinyl acetate	10 U	*
Bromodichloromethane	5 U	*
1,2-Dichloropropane	5 U	*
cis-1,3-Dichloropropene	5 U	*
Trichloroethene	5 U	*
Dibromochloromethane	5 U	*
1,1,2-Trichloroethane	5 U	*
Benzene	5 U	*
trans-1,3-Dichloropropene	5 U	*
Bromoform	5 U	*
4-Methyl-2-pentanone	10 U	*
2-Hexanone	10 U	*
Tetrachloroethene	5 U	*
1,1,2,2-Tetrachloroethane	5 U	*
Toluene	5 U	*
Chlorobenzene	5 U	*
Ethyl benzene	5 U	*
Styrene	5 U	*
Xylene, total	5 U	*

* : RCRA limits are not directly comparable to aqueous samples.

See Table 4.3-28 for an explanation of the data qualifiers.

Laboratory results are located in Appendix G.

The only positively identified organic compound was acetone and may be considered to be a laboratory contaminant, the sludge is likely very low in volatile organics. Table 4.3-22 presents the radionuclide data for the sludge sample. No conclusions were made regarding the acceptability of the radionuclide data.

4.3.3.6 Quality Assurance/Quality Control Samples

In addition to the field sampling required to evaluate the treatment system influent and effluent, QA/QC samples were taken in accordance with the sampling program which was outlined in the QA/QC Plan. Field sampling was conducted in accordance with the plan with respect to duplicates, field blanks, trip blanks, matrix spikes and matrix spike duplicates. Although QA/QC samples were taken from both the Grace treatment plant and the UniFirst treatment plant, samples from both treatment plants were delivered to the analytical laboratory as one sample delivery group (SDG). Since the required number of QA/QC samples is based on SDGs, not all of the QA/QC samples needed to be analyzed. Sufficient QA/QC samples were analyzed to meet the quality assurance objectives established in the QA/QC Plan, both in the field and in the laboratory. For the purposes of cost minimization and expediency, these extra samples were not analyzed and do not impact the quality of work which was conducted.

Field duplicate samples and blank samples which were not presented in previous tables are presented in Tables 4.3-23 through 4.3-26 for comparison with their corresponding field samples. In virtually all instances, field blanks contained no contaminants and field duplicates were within acceptable limits for positively identified compounds.

QA/QC Review

The objective of the QA/QC program was to produce documented data of known quality so that it could be used to confidently make decisions regarding the project. This objective was achieved by ensuring all activities were performed correctly through quality control checks which consisted of method blanks, duplicate and matrix spike samples, standards, surrogates, and field blanks. A detailed description of the QA/QC procedures is contained within the QA/QC Plan. These procedures were used to assess the precision, accuracy, completeness, representativeness, and comparability of the analytical data. The results obtained for the samples were reviewed by the laboratory QA manager and then an independent data validator (Trillium). This data was reduced by a combination of statistical procedures and qualitative evaluations and compared to the acceptance limits established in the QA/QC Plan. Data were not eliminated from the database based on the results of statistical analyses. If the data deviates from previous analyses or surrounding conditions, it has been annotated. The QA/QC review conducted by Trillium is included in Appendix K. In addition to the overall project QA/QC review which was included in the Work Plan, a brief summary of the samples which were taken in accordance with the QA/QC

TABLE 4.3-22

Grace Pilot Plant
Sludge Sample
Radionuclide Results

All results in pCi/gm

SAMPLE ID		SLUDGE CU
DATE SAMPLED		5/23/91
Gross Alpha		20 +/-7
Gross Beta		48 +/-4
Radium-228		0.59 +/-0.29

pCi/gm : picoCuries per gram

Laboratory results are located in Appendix G.

TABLE 4.3-23

Grace Pilot Plant
Semi-Volatile Duplicate Concentrations

All results in ug/L

SAMPLE ID	V131S1FD	V131S5FD	V131S10FD						
SAMPLE LOCATION	INFLUENT V-131								
DAY OF RUN	DAY 1	DAY 5	DAY 10						
DATE SAMPLED	5/10/91	5/14/91	5/19/91						
Phenol	10 U	10 U	10 U						
bis(2-Chloroethyl)ether	10 U	10 U	10 U						
2-Chlorophenol	10 U	10 U	10 U						
1,3-Dichlorobenzene	10 U	10 U	10 U						
1,4-Dichlorobenzene	10 U	10 U	10 U						
Benzyl alcohol	10 U	10 U	10 U						
1,2-Dichlorobenzene	10 U	1 J	10 U						
2-Methylphenol	10 U	10 U	10 U						
bis(2-Chloroisopropyl)ether	10 U	10 U	10 U						
4-Methylphenol	10 U	10 U	10 U						
N-Nitroso-di-n-propylamine	10 U	10 U	10 U						
Hexachloroethane	10 U	10 U	10 U						
Nitrobenzene	10 U	10 U	10 U						
Isophorone	10 U	10 U	10 U						
2-Nitrophenol	10 U	10 U	10 U						
2,4-Dimethylphenol	10 U	10 U	10 U						
Benzoic acid	50 U	50 U	50 U						
bis(2-Chloroethoxy)methane	10 U	10 U	10 U						
2,4-Dichlorophenol	10 U	10 U	10 U						
1,2,4-Trichlorobenzene	10 U	10 U	10 U						
Naphthalene	10 U	10 U	10 U						
4-Chloroaniline	10 U	10 U	10 U						
Hexachlorobutadiene	10 U	10 U	10 U						
4-Chloro-3-methylphenol	10 U	10 U	10 U						
2-Methylnaphthalene	10 U	10 U	10 U						
Hexachlorocyclopentadiene	10 U	10 U	10 U						
2,4,6-Trichlorophenol	10 U	10 U	10 U						
2,4,5-Trichlorophenol	50 U	50 U	50 U						
2-Chloronaphthalene	10 U	10 U	10 U						
2-Nitroaniline	50 U	50 U	50 U						
Dimethylphthalate	10 U	10 U	10 U						
Acenaphthylene	10 U	10 U	10 U						
2,6-Dinitrotoluene	10 U	10 U	10 U						

See Table 4.3-28 for an explanation of the data qualifiers.

Laboratory results are located in Appendix G.

TABLE 4.3-23 (cont.)

				All results in ug/L					
SAMPLE ID	V131S1FD	V131S5FD	V131S10FD						
SAMPLE LOCATION	INFLUENT V-131								
DAY OF RUN	DAY 1	DAY 5	DAY 10						
DATE SAMPLED	5/10/91	5/14/91	5/19/91						
3-Nitroaniline	50 U	50 U	50 U						
Acenaphthene	10 U	10 U	10 U						
2,4-Dinitrophenol	50 U	50 U	50 U						
4-Nitrophenol	50 U	50 U	50 U						
Dibenzofuran	10 U	10 U	10 U						
2,4-Dinitrotoluene	10 U	10 U	10 U						
Diethylphthalate	10 U	10 U	10 U						
4-Chlorophenyl-phenylether	10 U	10 U	10 U						
Fluorene	10 U	10 U	10 U						
4-Nitroaniline	50 U	50 U	50 U						
4,6-Dinitro-2-methylphenol	50 U	50 U	50 U						
N-Nitrosodiphenylamine	10 U	10 U	10 U						
4-Bromophenyl-phenylether	10 U	10 U	10 U						
Hexachlorobenzene	10 U	10 U	10 U						
Pentachlorophenol	50 U	50 U	50 U						
Phenanthrene	10 U	10 U	10 U						
Anthracene	10 U	10 U	10 U						
Di-n-butylphthalate	10 U	10 U	10 U						
Fluoranthene	10 U	10 U	10 U						
Pyrene	10 U	10 U	10 U						
Butylbenzylphthalate	10 U	10 U	10 U						
3,3'-Dichlorobenzidine	20 U	20 U	20 U						
Benzo(a)anthracene	10 U	10 U	10 U						
Chrysene	10 U	10 U	10 U						
bis(2-Ethylhexyl)phthalate	10 U	10 U	10 U						
Di-n-octylphthalate	10 U	10 U	10 U						
Benzo(b)fluoranthene	10 U	10 U	10 U						
Benzo(k)fluoranthene	10 U	10 U	10 U						
Benzo(a)pyrene	10 U	10 U	10 U						
Indeno(1,2,3-cd)pyrene	10 U	10 U	10 U						
Dibenzo(a,h)anthracene	10 U	10 U	10 U						
Benzo(g,h,i)perylene	10 U	10 U	10 U						

See Table 4.3-28 for an explanation of the data qualifiers.

Laboratory results are located in Appendix G.

TABLE 4.3-24

Grace Pilot Plant
Pesticides and PCB Duplicate Concentrations

All results in ug/L

SAMPLE ID	V131P1FD	V131P5FD	V131P10FD	V140P1FD			
SAMPLE LOCATION	INFLUENT V-131			EFFLUENT V-140			
DAY OF RUN	DAY 1	DAY 5	DAY 10	DAY 1			
DATE SAMPLED	5/10/91	5/14/91	5/19/91	5/10/91			
alpha-BHC	0.050 U	0.050 U	0.050 U	0.050 U			
beta-BHC	0.050 U	0.050 U	0.050 U	0.050 U			
delta-BHC	0.050 U	0.050 U	0.050 U	0.050 U			
gamma-BHC	0.050 U	0.050 U	0.050 U	0.050 U			
Heptachlor	0.050 U	0.050 U	0.050 U	0.050 U			
Aldrin	0.050 U	0.050 U	0.050 U	0.050 U			
Heptachlor epoxide	0.050 U	0.050 U	0.050 U	0.050 U			
Endosulfan I	0.050 U	0.050 U	0.050 U	0.050 U			
Dieldrin	0.10 U	0.10 U	0.10 U	0.10 U			
4,4'-DDE	0.10 U	0.10 U	0.10 U	0.10 U			
Endrin	0.10 U	0.10 U	0.10 U	0.10 U			
Endosulfan II	0.10 U	0.10 U	0.10 U	0.10 U			
4,4'-DDD	0.10 U	0.10 U	0.10 U	0.10 U			
Endosulfan sulfate	0.10 U	0.10 U	0.10 U	0.10 U			
4,4'-DDT	0.10 U	0.10 U	0.10 U	0.10 U			
Methoxychlor	0.50 U	0.50 U	0.50 U	0.50 U			
Endrin ketone	0.10 U	0.10 U	0.10 U	0.10 U			
alpha-Chlordane	0.50 U	0.50 U	0.50 U	0.50 U			
gamma-Chlordane	0.50 U	0.50 U	0.50 U	0.50 U			
Toxaphene	1.0 U	1.0 U	1.0 U	1.0 U			
Aroclor-1016	0.50 U	0.50 U	0.50 U	0.50 U			
Aroclor-1221	0.50 U	0.50 U	0.50 U	0.50 U			
Aroclor-1232	0.50 U	0.50 U	0.50 U	0.50 U			
Aroclor-1242	0.50 U	0.50 U	0.50 U	0.50 U			
Aroclor-1248	0.50 U	0.50 U	0.50 U	0.50 U			
Aroclor-1254	1.0 U	1.0 U	1.0 U	1.0 U			
Aroclor-1260	1.0 U	1.0 U	1.0 U	1.0 U			

See Table 4.3-28 for an explanation of the data qualifiers.
Laboratory results are located in Appendix G.

TABLE 4.3-25

Grace Pilot Plant
Total Influent Duplicates - (V131)
VOC Concentrations

All results in ug/L

SAMPLE ID	V131V1FD	V131V2FD	V131V3FD		V131V5FD	V131V6FD		V131V8FD		V131V10FD	
DAY OF RUN	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7	DAY 8	DAY 9	DAY 10	DAY 11
DATE SAMPLED	5/10/91	5/11/91	5/12/91	5/13/91	5/14/91	5/15/91	5/16/91	5/17/91	5/18/91	5/19/91	5/20/91
Chloromethane	100 U	100 U	100 U		100 U	100 U		100 U		100 U	
Bromomethane	100 U	100 U	100 U		100 U	100 U		100 U		100 U	
Vinyl chloride	760	1100	930		520	490		360		320	
Chloroethane	100 U	100 U	100 U		100 U	100 U		100 U		100 U	
Methylene chloride	50 U	50 U	50 U		50 U	50 U		50 U		50 U	
Acetone	100 U	100 U	100 U		100 U	100 U		100 U		100 U	
Carbon disulfide	50 U	50 U	50 U		50 U	50 U		50 U		50 U	
1,1-Dichloroethene	50 U	50 U	50 U		50 U	50 U		50 U		50 U	
1,1-Dichloroethane	50 U	50 U	50 U		50 U	50 U		50 U		50 U	
1,2-Dichloroethene, total	1300	1200	1200		1000	1000		960		850	
Chloroform	50 U	50 U	50 U		50 U	50 U		50 U		50 U	
1,2-Dichloroethane	50 U	50 U	50 U		50 U	50 U		50 U		50 U	
2-Butanone	100 U	100 U	100 U		100 U	100 U		100 U		100 U	
1,1,1-Trichloroethane	50 U	50 U	50 U		50 U	50 U		50 U		50 U	
Carbon tetrachloride	50 U	50 U	50 U		50 U	50 U		50 U		50 U	
Vinyl acetate	100 U	100 U	100 U		100 U	100 U		100 U		100 U	
Bromodichloromethane	50 U	50 U	50 U		50 U	50 U		50 U		50 U	
1,2-Dichloropropane	50 U	50 U	50 U		50 U	50 U		50 U		50 U	
cis-1,3-Dichloropropene	50 U	50 U	50 U		50 U	50 U		50 U		50 U	
Trichloroethene	310	310	330		400	420		480		420	
Dibromochloromethane	50 U	50 U	50 U		50 U	50 U		50 U		50 U	
1,1,2-Trichloroethane	50 U	50 U	50 U		50 U	50 U		50 U		50 U	
Benzene	50 U	50 U	50 U		50 U	50 U		50 U		50 U	
trans-1,3-Dichloropropene	50 U	50 U	50 U		50 U	50 U		50 U		50 U	
Bromoform	50 U	50 U	50 U		50 U	50 U		50 U		50 U	
4-Methyl-2-pentanone	100 U	100 U	100 U		100 U	100 U		100 U		100 U	
2-Hexanone	100 U	100 U	100 U		100 U	100 U		100 U		100 U	
Tetrachloroethene	50 U	50 U	50 U		50 U	50 U		24 J		27 J	
1,1,2,2-Tetrachloroethane	50 U	50 U	50 U		50 U	50 U		50 U		50 U	
Toluene	50 U	50 U	50 U		50 U	50 U		50 U		50 U	
Chlorobenzene	50 U	50 U	50 U		50 U	50 U		50 U		50 U	
Ethyl benzene	50 U	50 U	50 U		50 U	50 U		50 U		50 U	
Styrene	50 U	50 U	50 U		50 U	50 U		50 U		50 U	
Xylene, total	50 U	50 U	50 U		50 U	50 U		50 U		50 U	

See Table 4.3-28 for an explanation of the data qualifiers.

Laboratory results are located in Appendix G.

TABLE 4.3-26

Grace Pilot Plant
Daily Trip Blanks
VOC Concentrations

All results in ug/L

SAMPLE ID	V131V1TB	V131V1TB	V131V1TB	V131V1TB	V131V1TB	V131V1TB	V131V1TB	V131V1TB	V131V1TB	V131V1TB	V131V1TB
DAY OF RUN	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7	DAY 8	DAY 9	DAY 10	DAY 11
DATE SAMPLED	5/10/91	5/11/91	5/12/91	5/13/91	5/14/91	5/15/91	5/16/91	5/17/91	5/18/91	5/19/91	5/20/91
Chloromethane	10 U	NA	10 U	10 U	10 U	10 U	10 U	100 U	NA	10 U	0.5 U
Bromomethane	10 U	NA	10 U	10 U	10 U	10 U	10 U	100 U	NA	10 U	0.5 U
Vinyl chloride	10 U	NA	10 U	10 U	10 U	10 U	10 U	100 U	NA	10 U	0.5 U
Chloroethane	10 U	NA	10 U	10 U	10 U	10 U	10 U	100 U	NA	10 U	0.5 U
Methylene chloride	11	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	1 B
Acetone	10 U	NA	10 U	10 U	2 J	10 U	2 J	65	NA	10 U	0.5 U
Carbon disulfide	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.5 U
1,1-Dichloroethene	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.5 U
1,1-Dichloroethane	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.5 U
1,2-Dichloroethene, total	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.5 U
Chloroform	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.5 U
1,2-Dichloroethane	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.5 U
2-Butanone	10 U	NA	10 U	10 U	10 U	10 U	10 U	100 U	NA	10 U	0.5 U
1,1,1-Trichloroethane	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.5 U
Carbon tetrachloride	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.5 U
Vinyl acetate	10 U	NA	10 U	10 U	10 U	10 U	10 U	100 U	NA	10 U	0.5 U
Bromodichloromethane	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.5 U
1,2-Dichloropropane	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.5 U
cis-1,3-Dichloropropene	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.5 U
Trichloroethene	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.2 J
Dibromochloromethane	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.5 U
1,1,2-Trichloroethane	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.5 U
Benzene	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.5 U
trans-1,3-Dichloropropene	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.5 U
Bromoform	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.5 U
4-Methyl-2-pentanone	10 U	NA	10 U	10 U	10 U	10 U	10 U	100 U	NA	10 U	0.5 U
2-Hexanone	10 U	NA	10 U	10 U	10 U	10 U	10 U	100 U	NA	10 U	0.5 U
Tetrachloroethene	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	6	0.5 U
1,1,2,2-Tetrachloroethane	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.5 U
Toluene	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.5 U
Chlorobenzene	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.5 U
Ethyl benzene	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.5 U
Styrene	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.5 U
Xylene, total	5 U	NA	5 U	5 U	5 U	5 U	5 U	50 U	NA	5 U	0.5 U

NA : W.R. Grace trip blank samples not analyzed; trip blank samples submitted by Unifirst were included in the sample delivery group.

See Table 4.3-28 for an explanation of the data qualifiers.

Laboratory results are located in Appendix G.

Plan specifically for Grace were assessed following Sections 3.0 and 12.0 of the Plan as a guideline and presented in Table 4.3-27. This evaluation is presented in addition to the entire project QA/QC assessment and specifically targets sampling efforts conducted on the Grace property in support of the treatability study.

Table 4.3-28 identifies the letters used as data qualifiers by the laboratory and by the data validator to further describe the reported results. These data qualifiers give additional information about the validity of and problems associated with the results, and are consistent with the EPA CLP methodology for qualifying data.

TABLE 4.3-27

Grace Pilot Plant
QA/QC Review

SAMPLES	METHOD	QTY	LAB	ACCURACY			PRECISION	REPRES.	COM-
				BLANK	MS	SURR	MSD	FIELD DUP	PLETE-
				< CRQL	ACCEPT.	ACCEPT.	< 30 %	< 30%	NESS
Influent	CLP VOA	47	P	83% (6:7)	92% (46:50)	100% (141:141)	92% (46:50)	94% (32:34)	100% (47:47)
Effluent	524.2	28	P	100% (13:13)	76% (38:50)	100% (84:84)	78% (39:50)	100% (1:1)*	100% (28:28)
Influent/Effluent	CLP SV	13	P	100% (3:3)	70% (31:44)	97% (76:78)	86% (38:44)	*	100% (13:13)
Influent/Effluent	Pest/PCB	13	P	100% (3:3)	46% (11:24)	100% (13:13)	42% (10:24)	*	100% (13:13)
Recovery Wells	CLP VOA	10	A	-	100% (5:5)	97% (29:30)	100% (5:5)	-	100% (10:10)
Optimization Trials	CLP VOA	5	A	-	-	100% (15:15)	-	-	100% (5:5)
Optimization Trials	524.2	7	A	100% (1:1)	-	100% (21:21)	-	-	100% (7:7)

Influent samples include all V131, V154 and V197 samples, duplicates and blanks.

Effluent samples include all V140 samples, duplicates and blanks.

MS and MSD include Unifirst sample data when included in the same SDG as W.R. Grace data.

* : Many field duplicates had no detected compounds in the sample or the duplicate; results are shown only for positive value comparisons.

- : No information was obtained for this parameter in the associated sample group.

LAB : P-PACE; A-Aquatec

TABLE 4.3-28

Sample Qualifiers

- U = This flag identifies compounds analyzed for but not detected.
- J = This flag indicates an estimated value. This flag is used either when estimating a concentration for a TIC where a 1:1 response is assumed, or when the mass spectral data indicates the presence of a compound that meets the identification criteria, but the result is less than the sample quantitation limit, but greater than zero. For example, if the sample quantitation limit is 10 µg/l, but a concentration of 3 µg/l is calculated, 3J will be reported. The sample quantitation limit is adjusted for both dilution and percent moisture so that if a sample with 24 percent moisture and a 1:10 dilution factor has a calculated concentration of 300 µg/l and a sample quantitation limit of 430 µg/kg, the concentration is reported as 300J on Form I.
- C = This flag applies to pesticides results where the identification has been confirmed by GC/MS. Single component pesticides ≥ 10 ng/ul in the final extract are confirmed by GC/MS.
- B = This flag is used when the analyte is found in the associated blank as well as in the sample. It indicates possible/probable blank contamination and warns the data user to take appropriate action. This flag is used for a TIC as well as for a positively identified TCL compound.
- E = This flag identifies compounds whose concentrations exceed the calibration range of the instrument for that specific analysis. If one or more compounds have a response greater than full scale, then the sample or extract will be diluted and reanalyzed. All such compounds with a response greater than full scale will have the concentration flagged with an "E" on the Form I for the original analysis. If the dilution of the extract causes any compounds identified in the first analysis to be below the calibration range in the second analysis, then the results of both analyses will be reported on separate Form I's. The Form I for the dilution sample will have the "DL" or "REDL" suffix appended to the sample number.
- D = This flag identifies all compounds identified in an analysis at a secondary dilution factor. If a sample or extract is reanalyzed at a higher dilution factor, the "DL" or "REDL" suffix is appended to the sample number on the Form I for the dilution sample, and all concentration values reported on that Form I are flagged with a "D".
- A = This flag indicates that a TIC is a suspected aldol-condensation product.

TABLE 4.3-28 (cont.)

- X = This flag is used to describe results that are not previously defined. It is fully described in the Case Narrative and such description as attached to the Sample Data Summary Package. If more than one flag is required, then "Y" and "Z" will be used. If more than five qualifiers are required for a sample results, then the "X" flag will be combined with several flags as needed. For example, the "X" flag may be combined with the "A", "B", or "D" flags.
- S = This flag indicates compounds that are added to the sample prior to analysis for purposes of quality control.

5.0 FINAL DESIGN SELECTION

5.1 UniFirst Treatment System

5.1.1 Design Basis

5.1.1.1 Ground-Water Extraction System

The water level monitoring results during the pilot treatment test at UniFirst indicated a substantial zone of influence from pumping at Well UC22 at a sustained rate of 50 gallons per minute (gpm). This zone of influence encompassed both the UniFirst and Grace properties, and therefore represents an effective hydraulic source control measure for bedrock contamination at these properties. The rate of long-term pumping is not expected to exceed 50 gpm since the magnitude of the zone of influence at that rate during the pilot test was sufficient. The pumping system will be controlled by drawdown in the well rather than a constant flow rate, since ambient water level elevations will fluctuate over time. As a result, the flow rate from the pumping may vary, but will not likely need to exceed 50 gpm.

5.1.1.2 Source Characterization

The proposed maximum flow rate from the UC22 pumping well of 50 gpm as developed in Section 5.1.1.1, has been used as the basis for hydraulic design of the final treatment system. Additional characterization of the source for the purposes of design must include a determination of the anticipated quality of the influent water. This can be done by reviewing the analytical data from the influent samples during the 30-day treatability test.

The goals of reviewing the influent data are to 1) identify compounds that require treatment in order to achieve discharge limits or discharge goals, 2) identify compounds that may impact the operation or treatment efficiency of the proposed treatment system but are not necessarily limited in the effluent, and 3) predict what the concentrations of these compounds will be in the influent during long term pumping for the purposes of designing the treatment system. With these goals in mind, and reviewing the data presented in Tables 4.2-4 through 4.2-8, it is clear that the compounds whose data need to be further analyzed are: 1) volatile organic compounds, the contaminants for which the treatment system is designed to remove, and 2) a few additional physical and inorganic parameters that have the potential to impact the operations of the proposed treatment system, but which are not target compounds requiring removal in order to meet remedial objectives or effluent limits. These two groups of compounds are discussed below.

As anticipated, no volatile organic compounds were detected in the pumped ground water during the treatability test that were not on the list of selected hazardous substances in the Record of Decision. And out of the nine compounds on that list, three were not significantly detected during the duration of the treatability test.

The compounds that were detected that the final treatment system will be designed to remove are:

- 1,1-dichloroethane
- 1,1-dichloroethene
- Tetrachloroethene
- Trichloroethene
- Trans,1,2-dichloroethene
- 1,1,1-trichloroethane

Other than tetrachloroethene, the other compounds listed above, were not detected by the laboratory. This does not mean that these compounds were not present since the detection limits were relatively high as a result of necessary laboratory dilutions. Dilutions were necessary because of the relatively high concentrations of tetrachloroethene in the influent. As a result, the full characterization of the influent must rely on the data from the A+RT Field Organics Analyzer System, which was able to detect and report low concentrations of the other compounds.

In order to evaluate the general trend of VOC concentrations in the influent during the treatability test, tetrachloroethene concentrations have been plotted versus time with concentrations of tetrachloroethene being plotted on an arithmetic scale on Figure 5.1-1 and on a logarithmic scale on Figure 5.1-2 for both the laboratory analytical data and the A+RT Field Organics Analyzer System data. These graphs indicate rapidly increasing concentrations during the first week of the treatability test, starting at 26 µg/L on day 1 of the test to 2200 µg/L on day 7. Concentrations continued to increase during the remainder of the test, however, at a steadily decreasing rate. This is reflected in Figure 5.1-2 that shows the trend in the laboratory data to be very closely logarithmic in nature, asymptotically approaching a maximum concentration. The A+RT data deviates more from a logarithmic approximation than does the laboratory.

The mathematical logarithmic expression representing the best fit curve to the laboratory analytical data (shown on Figure 5.1-2) predicts a tetrachloroethene concentration of 9441 µg/L after five years of pumping, and 10,349 µg/L after ten years of pumping. However, we expect the increasing concentration trend to reverse itself after a certain amount of mass has been removed from the system. Unfortunately, there is not enough experience on these types of sites to reasonably predict when that reversal will take place, and how strong the reversal will be. As

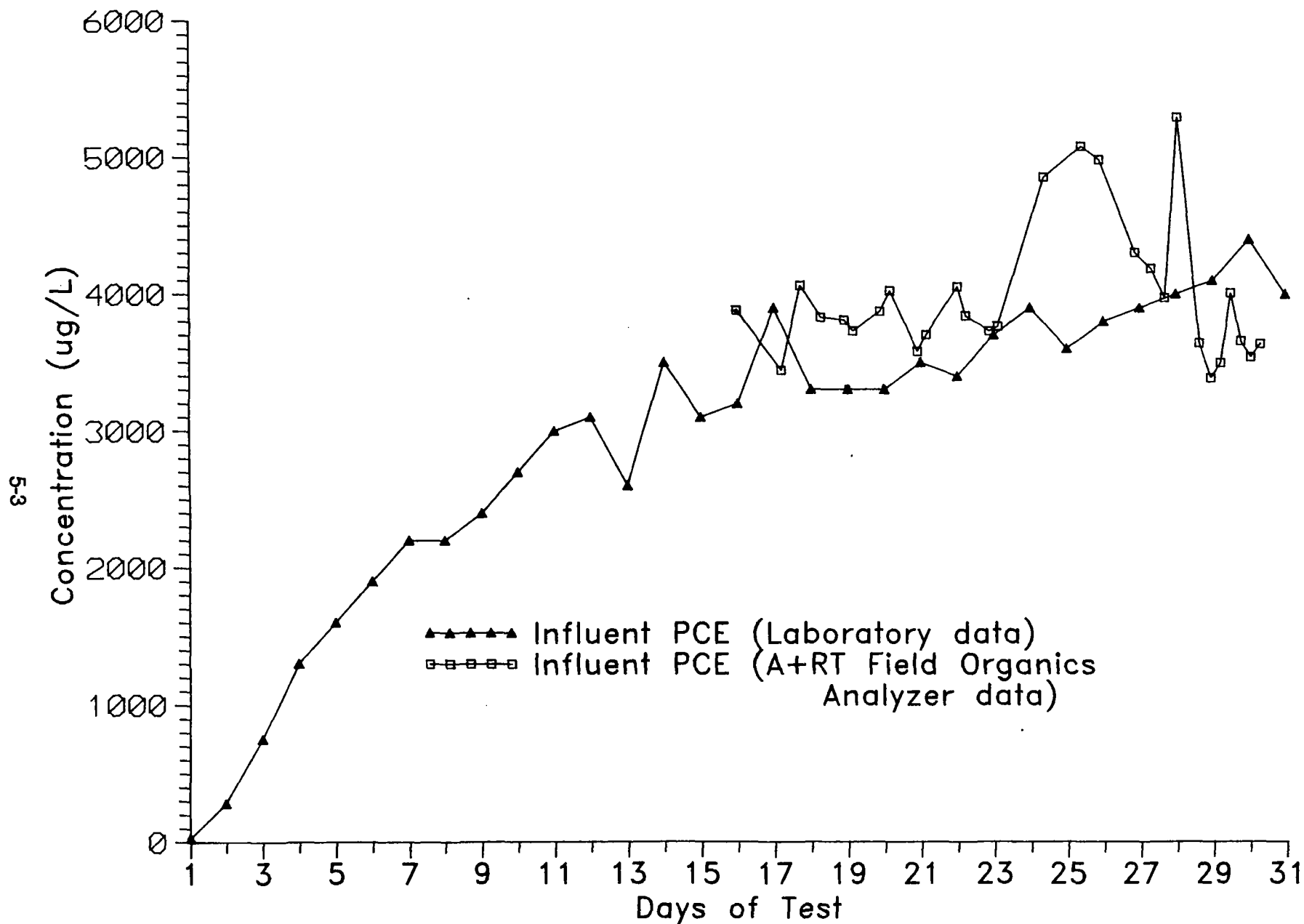
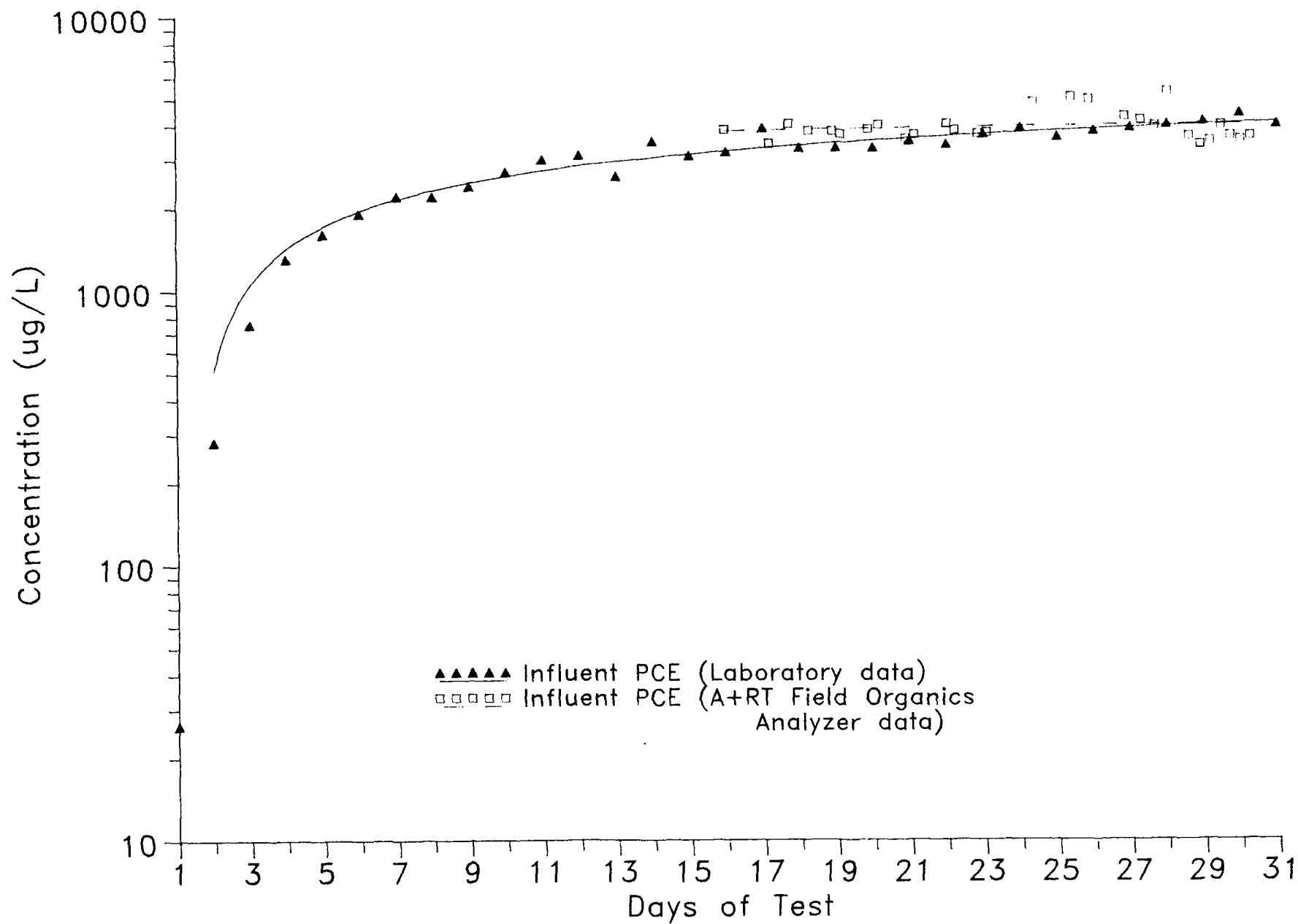


FIGURE 5.1-1

Influent Tetrachloroethene Concentration Versus Time

**FIGURE 5.1-2**

Influent

Tetrachloroethene Concentration vs. Time (Logarithmic Scale)

a point of reference, the total mass of tetrachloroethene that would have been removed from the system at a continuous flow rate of 50 gpm for a period of ten years, assuming the logarithmic relationship holds for that period of time, and that a reversal does not occur during that period, is about 1400 gallons of product. Although unsubstantiated, we do not believe that the nature and extent of the original releases of tetrachloroethene at this site warrants this assumption.

In any event, the treatment system has been designed to accommodate a wide range of influent concentrations. The basic design, and the basis for the operation and maintenance cost estimate in Volume II of this report, has assumed a total VOC loading into the UV system of about 5200 $\mu\text{g/L}$, with about 96% of the total being tetrachloroethene and 2% being trichloroethene. The other two percent will be distributed between trichloroethane, dichloroethene, and dichloroethane. These estimated percentages are based on a review of the influent data from the treatability test. The expected operational mode for the UV system based on these assumed influent concentrations of VOC is three-5KW UV bulbs being on and a hydrogen peroxide dose of 25 mg/L. The model UV unit that will be employed at this site will have six 5KW bulbs available and will be capable of injecting hydrogen peroxide up to concentrations over 100 mg/L, affording the capability to treat total VOC concentrations up to about 10,000 $\mu\text{g/L}$, which should be adequate to cover the possibility that the concentration trend does not reverse itself before ten years.

In addition to the UV treatment process, granular activated carbon tanks will be on-line continuously following the UV unit. If the influent total VOC concentrations approached 10,000 $\mu\text{g/L}$ over time, and the UV treatment unit efficiency was reduced, the carbon treatment step will continue to polish the effluent quality to achieve the desired discharge quality.

Additional physical and inorganic parameters that have the potential to impact the operation of the treatment system, and the nature of the potential impact, are shown in Table 5.1-1. Measurements made of these parameters during the treatability test are summarized in Tables 4.2-6, 4.2-8, 4.2-11, and 4.2-12.

Iron and manganese concentrations in the influent were relatively low and if those levels remain low during extended pumping they will not impact the operation or design of the final system. pH in the influent was acceptable for the purposes of UV/chemical oxidation treatment, and adjustment of pH in the final system will not be necessary. Also, the addition of hydrogen peroxide, and the resulting chemical conversion products from the degradation of the organic compounds, did not significantly alter the effluent pH, and we don't anticipate this occurrence in the final system, therefore, hardness and alkalinity will not affect the design or operation of the final system. Total suspended solids were not detected during a majority of the test, and although we are providing a multi-media filter in the final treatment system, it is only being

TABLE 5.1-1

Parameters Potentially Impacting the Final Treatment System Operation

<u>Parameter</u>	<u>Nature of Potential Impact</u>
Iron and manganese	Precipitation and plating on UV bulbs and fouling of carbon bed.
Hardness	Precipitation if pH is increased as a result of the treatment processes, and subsequent plating on UV bulbs, or fouling of carbon bed.
pH	Affects the effectiveness of the chemical feed system, and influences the undesirable precipitation of hardness causing compounds (e.g., calcium)
Hydrogen peroxide residual	Occupies adsorption sites on the carbon, potential impact on the receiving stream.
Total suspended solids	Creates turbidity which reduces the efficiency of the UV system, and can be retained by the carbon bed reducing its efficiency and requiring more frequent backwashing.
Alkalinity	Affects the chemistry of treatment if iron, manganese or hardness needed to be removed or if pH had to be adjusted in the final treatment system.
Total dissolved solids	Affects the chemistry of treatment if metals or other ions had to be removed in the final treatment.

provided as a safety factor to protect the subsequent treatment units in the event that at some time during the life of the system, or during start-up after pump down time, suspended solids show up in the influent.

Hydrogen peroxide residual was measured several times in the effluent from the UV system, and the effluent from the entire system. It is intentional for there to be some residual in the effluent from the UV system, since this is an indicator that the full oxidative potential of the chemical is being exercised within the oxidation chamber. The purpose of the optimization test was to vary the hydrogen peroxide dose in an effort to reduce the dose to the minimum needed, while still obtaining the full oxidation of the organic compounds within the treatment chambers. This process will be accomplished in the final system to minimize the hydrogen peroxide entering the carbon bed and occupying adsorption sites.

It is apparent from the field test results that the residual did not pass through the carbon bed and end up in the effluent.

5.1.1.3 Discharge Limits

The discharge limits for the UniFirst treatment system are based on the EPA Ambient Water Quality Criteria for Aquatic Life: Chronic Exposure. The limits are calculated values based on a mass balance between the discharge and the receiving stream, since the ambient water quality criteria should be applied to instream conditions rather than the discharge itself. The calculation has been done as follows:

$$\text{Discharge Limit} = \frac{(\text{Ambient Criteria}) (Q + 7Q_{10})}{Q}$$

Where: Ambient Criteria = EPA Ambient Water Quality Criteria for Aquatic Life: Chronic Exposure

Q = Discharge flow rate (50 gpm max)

7Q₁₀ = 7-day mean low flow on a 10 year recurrence interval for the Aberjona River

The 7Q₁₀ at the point of discharge into the Aberjona River is 0.22cfs (100 gpm). This was developed by first identifying the nearest USGS gaging station where 7Q₁₀ data has been developed. This station is at the crossing of the Aberjona River and Montvale Avenue (approximately 1.3 miles downstream of the point of discharge). The 7Q₁₀ at this station is 0.4 cfs (180 gpm) as developed by the USGS. The contributing drainage area at this station is 8.93 square miles. The drainage area upstream of the point of discharge is 4.94 square miles. The 7Q₁₀ at the point of discharge can therefore be roughly calculated by multiplying by the direct ratio of the respective drainage areas shown as follows:

$$\begin{aligned}
 7Q10 \text{ @ discharge point} &= \frac{4.94}{8.93} \times 7Q10 \text{ @ Montvale Ave.} \\
 &= 0.55 \times 0.45 \text{ cfs} \\
 &= 0.22 \text{ cfs (or 100 gpm)}
 \end{aligned}$$

Based on the mass balance equation above and the 7Q10 calculated, the discharge limit is 3.0 times the ambient criteria for each parameter. The ambient criteria and discharge limits for UniFirst are summarized on Table 2.2-3. As can be seen in Table 2.2-3, the ambient criteria for volatile organics are either extremely high (and sometimes based on very little data) or not yet developed. However, the treatment system has been designed to achieve effluent volatile organics concentrations of about 5 micrograms per liter to eliminate exposure hazards to workers and the public, prevent degradation of Aberjona River quality, and be consistent with the remedial objectives for this site.

5.1.2 Selected Final Design

The final remedial design for the UniFirst property involves two components: ground-water extraction and treatment of the extracted ground water. The final selected ground-water extraction system involves the continuous pumping of Well UC22 at a probable (and maximum) flow rate of 50 gpm from an approximate depth of 190 feet. The development of the proposed extraction system is presented in Section 3.3.1.

The treatability test demonstrated the ability of the UV system to adequately treat the contaminants in the pumped ground water. An alternate, but well proven technology, granular activated carbon, has also been identified as a viable primary treatment alternative for the contaminants identified in the influent samples during the treatability test. We believe that either of these alternatives would technically meet the treatment objectives at this site, and the final selection would depend on an economic comparison of the two. This has been accomplished on a preliminary design basis, and the most cost effective alternative for this site appears to be the U.V. technology. Variables that could shift the economic advantage back to carbon include the following:

1. A dramatic increase in the cost of electricity,
2. A dramatic decrease in the VOC concentrations during the early years of pumping.

On the other hand, if vinyl chloride begins appearing in the influent, the UV system will be much more efficient at removing that compound.

The overall treatment system selected for the UniFirst property includes the unit processes indicated in Table 5.1-2. Also included in Table 5.1-2 are the individual functions of each unit

TABLE 5.1-2

Summary of the Proposed UniFirst Treatment
Processes and Their Function

<u>Treatment Process</u>	<u>Primary Function</u>
1. Multi-media pressure filter	Removes silt and suspended solids from the groundwater. Turbidity can reduce the efficiency of the U.V. Chemical Oxidation system and clog the carbon bed.
2. U.V./Chemical oxidation.	Eliminates organic compounds.
3. Carbon Tanks (two at 25 gpm each)	Final polishing step for VOC removal. It will function as the VOC removal process in the event that the UV/Chemical oxidation system needs to be temporally by-passed for adjustment or maintenance.

process. A preliminary process equipment layout is presented in Figure 5.1-3, showing the proposed piping and valving arrangement. Figure 5.1-4 shows a site plan for UniFirst indicating the location of well UC22, the influent pipe, the treatment area, and the effluent pipe.

The proposed remedial strategy for the UniFirst source area has been designed to maximize the likelihood of accomplishing the remedial objectives for contaminated ground water at the UniFirst source area, as indicated in the EPA Administrative Order. These objectives, and a description of how the remedial design will facilitate meeting these objectives, is listed below.

1) Prevent further migration of contaminated ground water from the source areas to the central area:

This source control objective will be essentially met by the proposed remedial design through the creation of a hydraulic capture zone as a result of continuous pumping of well UC22. As discussed in Section 3.1, a pumping rate of 50 gpm creates a capture zone that extends beyond the source areas identified at the UniFirst and Grace properties, and therefore will prevent further migration of contaminants from these areas into the Central Area.

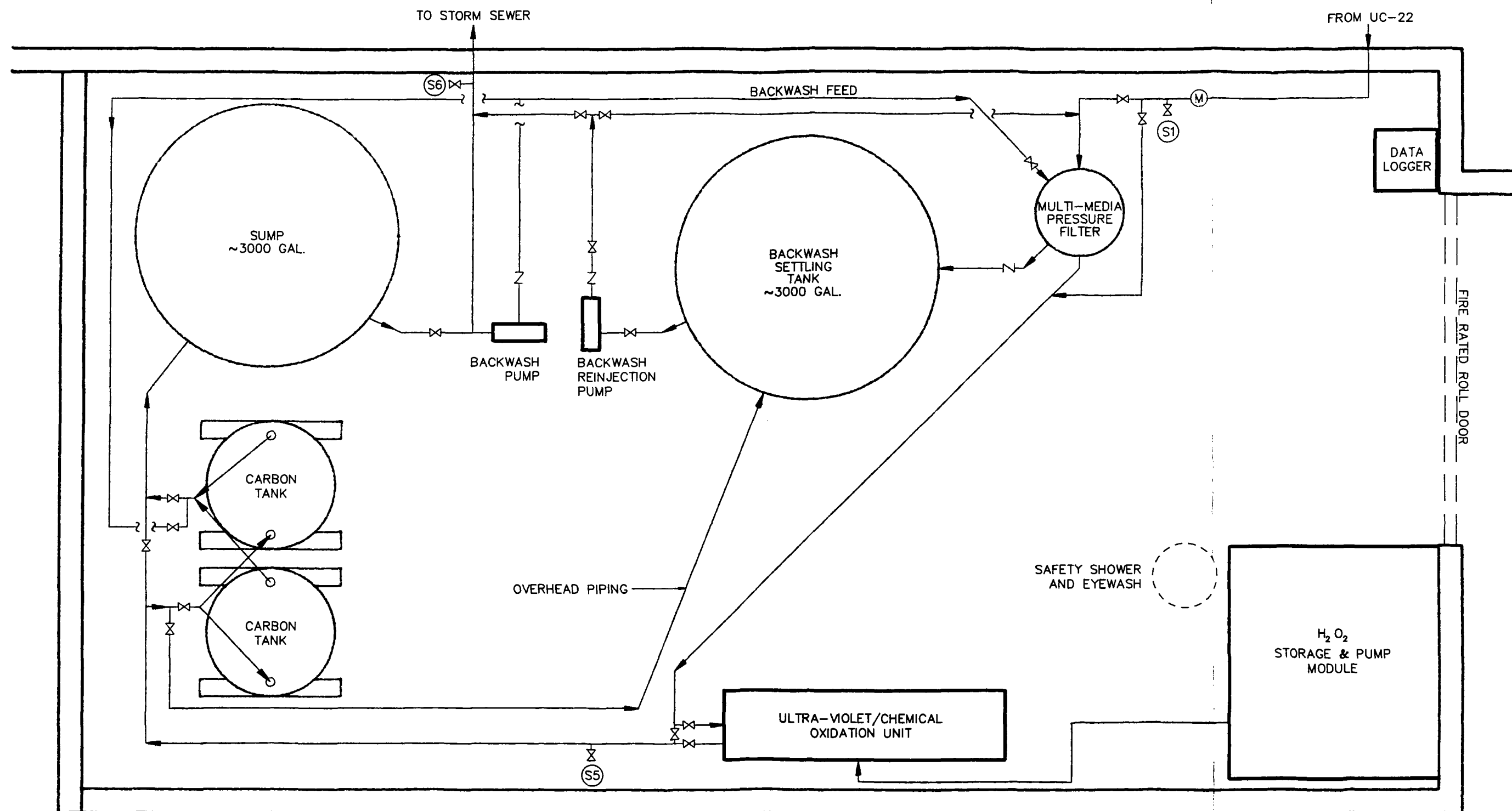
2) Restore the ground water in the vicinity of the source areas to cleanup levels:

Contaminant mass will be removed from the UniFirst and Grace source areas as a result of the remedial action designed for the Northeast Quadrant. This design involves the continuous pumping of ground water out of the bedrock zones. The extracted ground water will be contaminated as a result of DNAPL compounds solubilizing into the passing water. The design provides for the removal of these contaminants from the pumped ground water through a treatment system. Although there is no known effective strategy to directly extract the DNAPL from the bedrock fractures, the indirect removal of the DNAPL compounds, as provided for in this remedial design, will eventually result in decreasing concentrations of contaminants in the ground water, which ultimately will approach the clean-up levels.

3) Prevent public contact with contaminated ground water above the cleanup levels:

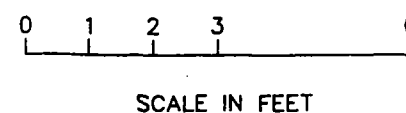
The only potential for public contact with contaminated ground water is with the raw ground water once it is pumped to the surface. The remedial design minimizes that potential through effective treatment of the water prior to discharge, and physically restricting access to the piping and treatment equipment that will be handling the water.

The effectiveness of the selected primary treatment technology (U.V.) in removing the contaminants of concern from the ground water has been adequately demonstrated during the treatability study. In addition, a second, redundant treatment step (granular activated carbon) is



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- ⊗ (S2) SAMPLING PORT
- ⊗ GATE VALVE
- (M) FLOW METER
- Z CHECK VALVE

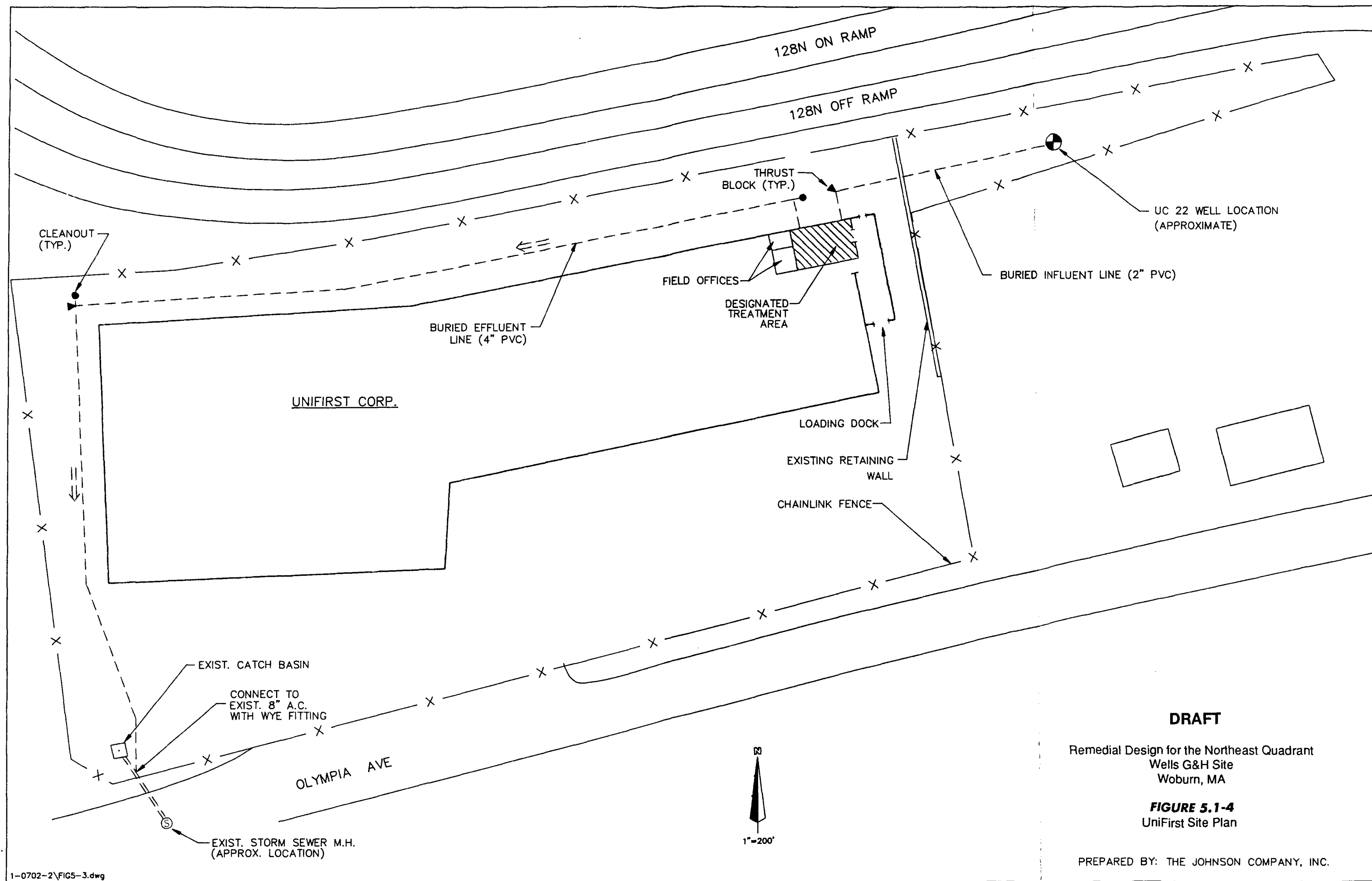


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Remedial Design for the Northeast Quadrant
Wells G&H Site
Woburn, MA

FIGURE 5.1-3
Unifirst Final Treatment System Layout

PREPARED BY: THE JOHNSON COMPANY, INC.



included in the design and that step will ensure that no contaminants are present in the effluent. Physical access to the system will be restricted by way of the buried piping and the security provisions for the treatment equipment room. The pumped ground water will flow directly from the well through a pitless adaptor below the ground, that will connect to a buried influent pipe. This pipe will run from the well to the UniFirst building underground, and enter the treatment room through the foundation wall and up through the interior slab. The treatment room will have limited access through doors that will normally be locked. The security measures are well defined in the Security Plan, a part of the final design documents for the UniFirst Treatment System: Volume II.

Pending release of the draft Technology Demonstration Report by the EPA's Environmental Monitoring Systems Laboratory at Las Vegas (EMSL-LV), UniFirst's proposed final design will integrate the A+RT Automated Volatile Organics Analysis System (AVOAS), which is described in Section 4.2.3.2 and in Appendix J. Currently, the success of the demonstration of this technology during the pilot test provides sufficient basis for UniFirst to include the AVOAS in the final design as the means of providing volatile organics analyses for long-term monitoring of the treatment-plant influent, process and effluent water and ground water that are required by the long-term monitoring plan, which is described in Volume II.

5.2 Grace Treatment System

The method of treatment for the final design for the Grace property is UV/Chemical Oxidation. Section 4.3.3 establishes that UV/chemical oxidation is extremely effective in removing the contaminants of concern for the characterized ground water on the Grace property. Therefore, the second and third specific objectives of the study stated in Section 1.2 have been achieved.

The following sections summarize the preceeding sections that specifically deal with the Grace property proposed ground-water recovery system and treatment system. Final conceptual design is then presented with a lead into Volume III which presents the final remedial design (i.e., the "nuts and bolts") in its entirety.

5.2.1 Design Basis

The final design of the treatment plant is based on three criteria:

1. Established design flow rate based on the proposed ground-water extraction system;
2. Specific chemical constituents targeted for treatment and their expected concentrations;
3. The discharge limits the design must meet for the specific chemical constituents being treated.

5.2.1.1 Ground-Water Extraction System

The maximum anticipated influent flowrate is 20 gpm. This is based on the extraction system proposed in Section 5.2.1, which is composed of four ground-water extraction areas (Figure 5.2-1). The flows are calculated from the treatability study flow data and hydrogeological response.

Area One: This area consists of the six source area wells along the southeastern wall of the main building. Anticipated flows from these wells are:

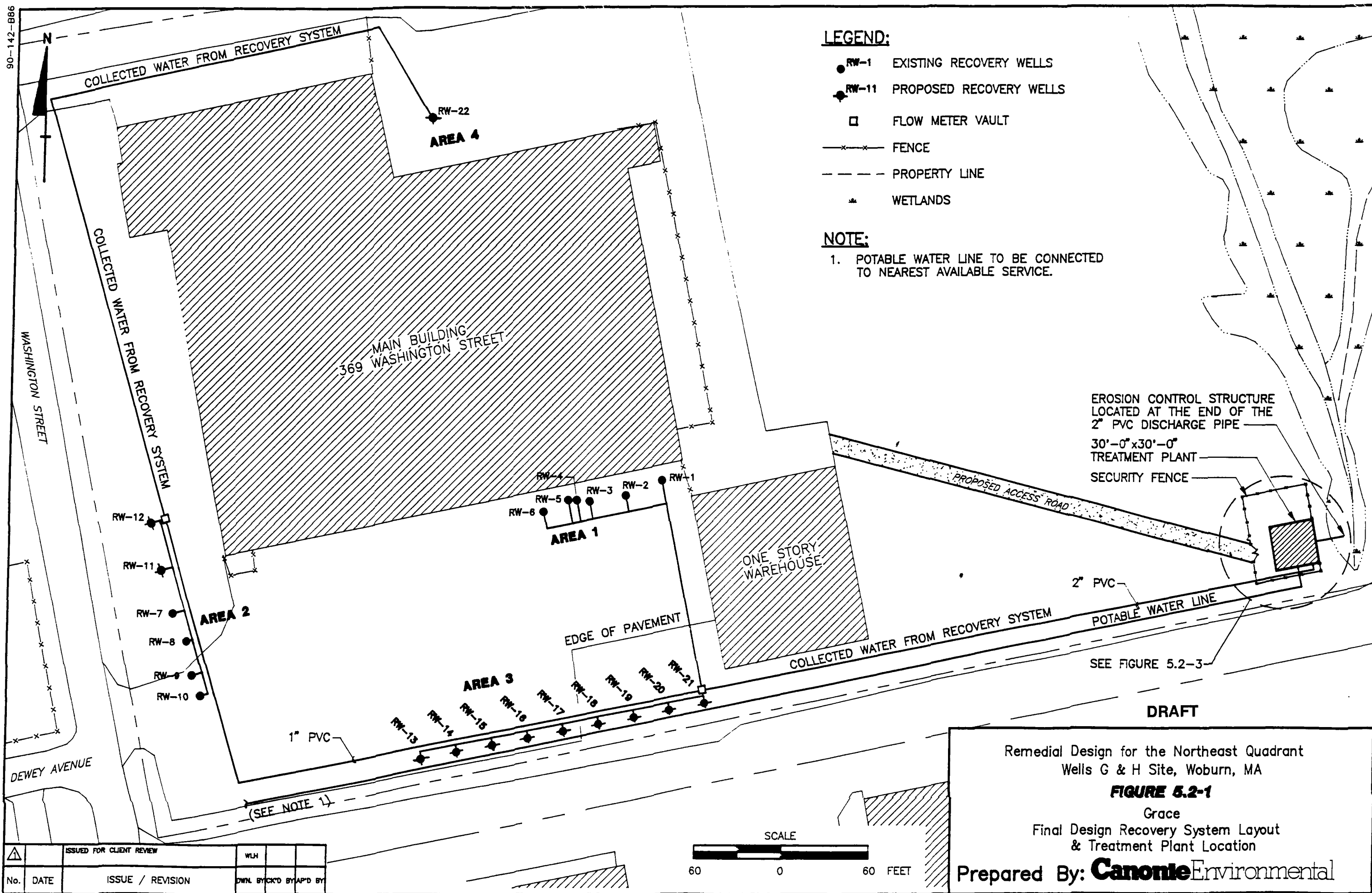
<u>Well</u>	<u>Flow rate (gpm)</u>
RW-1	<0.2
RW-2	<1.2
RW-3	<0.2
RW-4	<0.2
RW-5	<0.2
RW-6	<0.2
Total	<2.2 gpm

Area Two: This area consists of the six downgradient property boundary wells (four existing wells and two new wells) along the west southwest edge of the property. Anticipated flows from these wells are:

<u>Level</u>	<u>Flow rate (gpm)</u>
RW-7	<2.0
RW-8	<2.0
RW-9	<2.0
RW-10	<2.0
RW-11	<2.0
RW-12	<2.0
Total	<12 gpm

Area Three: This area consists of a line of about 9 extraction wells spaced 30-feet apart. Flow rate from the line of wells is expected to be less than 5 gpm.

Area Four: This area consists of a 3 foot diameter recovery well with an expected flow rate of less than 0.5 gpm.



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5.2.1.2 Source Characterization

Based upon the analytical results (Section 4.3.3) from the treatability study, the final treatment system will be designed to treat only volatile organic chemicals. Semi-volatile organics, pesticides/PCB, metals, radionuclides, and miscellaneous inorganics were either not detected or were detected at background levels, and therefore were not considered in the final design of the treatment system.

Based on the treatability study and the Remedial Investigation (RI) only four contaminants of concern are expected; Trichloroethene, 1,2-Dichloroethene, vinyl chloride, and tetrachloroethene. The expected concentrations of these compounds from the four pumping areas and in the influent to the treatment plant are listed below:

<u>Contaminants of Concern</u>	<u>Expected Mean Concentrations (µg/L)</u>				
	<u>Area 1</u>	<u>Area 2</u>	<u>Area 3</u>	<u>Area 4</u>	<u>Influent</u>
Vinyl chloride	1394	<50	74	<50	210
Trichloroethene	138	402	220	4900	440
1,2-Dichloroethene (total)	1589	403	143	150	460
Tetrachloroethene	<50	<25	<25	40	<30

These concentrations were averages calculated from the treatability study analytical data for areas one and two and from the RI analytical data for areas three and four.

5.2.1.3 Effluent Limits

The discharge limits for the final design have been established by the EPA to be the Fresh Water Chronic Criteria for Aquatic Life. These are listed in Table 2.2-3. These limits were selected because the intended discharge location on the Grace property for the final design is the creek bordering the wetlands to the east.

5.2.2 Selected Final Design

The remedial objectives, as detailed in the Consent Order (U.S. EPA, 1990) are:

- To prevent further migration of contaminated ground water from the source areas to the Central Area;
- To restore the ground water in the vicinity of the source areas to cleanup levels;
- To prevent public contact with contaminated ground water above the cleanup levels.

The final design ground-water extraction system described in Section 3.3.2 and again in Section 4.3.1.2 will prevent off-site migration of contaminated water and eventually restore the ground water to cleanup levels. The extraction system and the final treatment plant is designed to prevent public contact with ground water above cleanup levels. The following paragraphs detail the components of the selected final treatment plant design.

The process flow diagram and treatment plant layout for the final design is shown on Figures 5.2-2 and 5.2-3, respectively. This process is similar to the system designed for the treatability study. It consists of the UV/oxidation unit, peroxide injection system, two bag filters, a pump tank, and two centrifugal recirculation pumps. The EQ tank and temporary holding tanks will not be necessary for the final design because the treatment technology has been demonstrated to be capable of meeting the discharge limits.

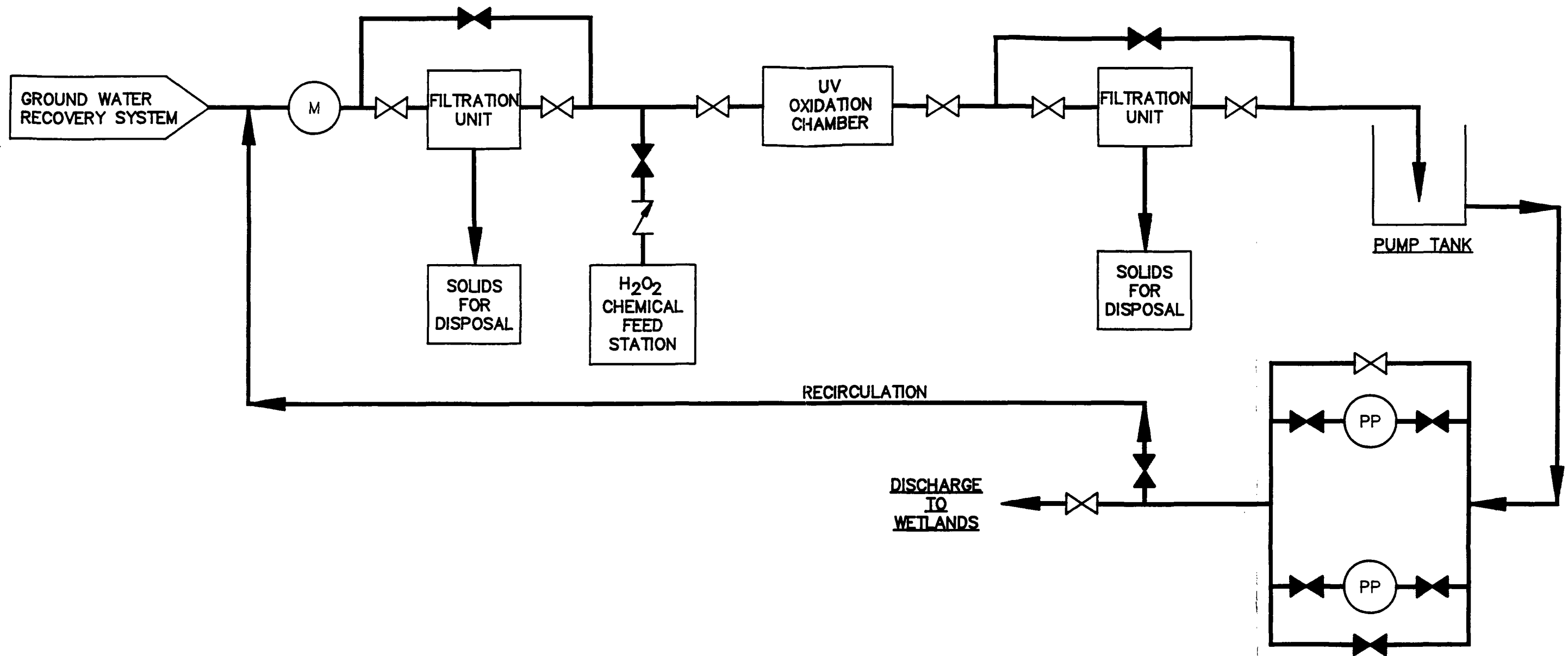
UV/Oxidation Unit

The UV/oxidation unit was designed based on the optimization trials data discussed in Section 4.3.3.4. Based on this data, a UV/oxidation unit with two 4-KW lamps will provide maximum removal efficiency while maintaining some redundancy and minimizing cost. A 4-KW lamp is the smallest lamp currently available. One lamp will provide a UV/dose of 3.3 KWhr/1,000 gal at a maximum design flow of 20 gpm. Both lamps operating will provide a UV dose of 6.6 KWhr/1,000 gal. If one lamp fails, sufficient UV dose will still be maintained with one lamp, preventing system shutdown until the defective lamp is replaced. This will prevent any unnecessary downtime. The UV/chemical oxidation unit, based on this design, is capable of reducing the contaminant concentrations to less than 1 µg/L.

The UV/oxidation unit will also be supplied with a transmittance controller for each lamp to prevent clouding of the quartz housing surrounding the lamps (see Section 4.3.1.2). Contingencies and system control is discussed at the end of this section under control/data acquisition system.

Peroxide Injection System

The peroxide injection system is designed to maintain a concentration of 30 mg/L in the influent. This is based on the optimization trials discussed in Section 4.3.3.4. Two programmable metering pumps will be installed to provide redundancy. A feedback system from the influent flowmeter through an integrated control system will adjust the speed of the metering pumps to maintain a set concentration of peroxide through varying influent flowrates.



LEGEND:

- | | | | |
|--|------------|--|--------------------|
| | PUMPS | | BALL VALVE (CLOSE) |
| | FLOW METER | | BALL VALVE (OPEN) |
| | | | CHECK VALVE |

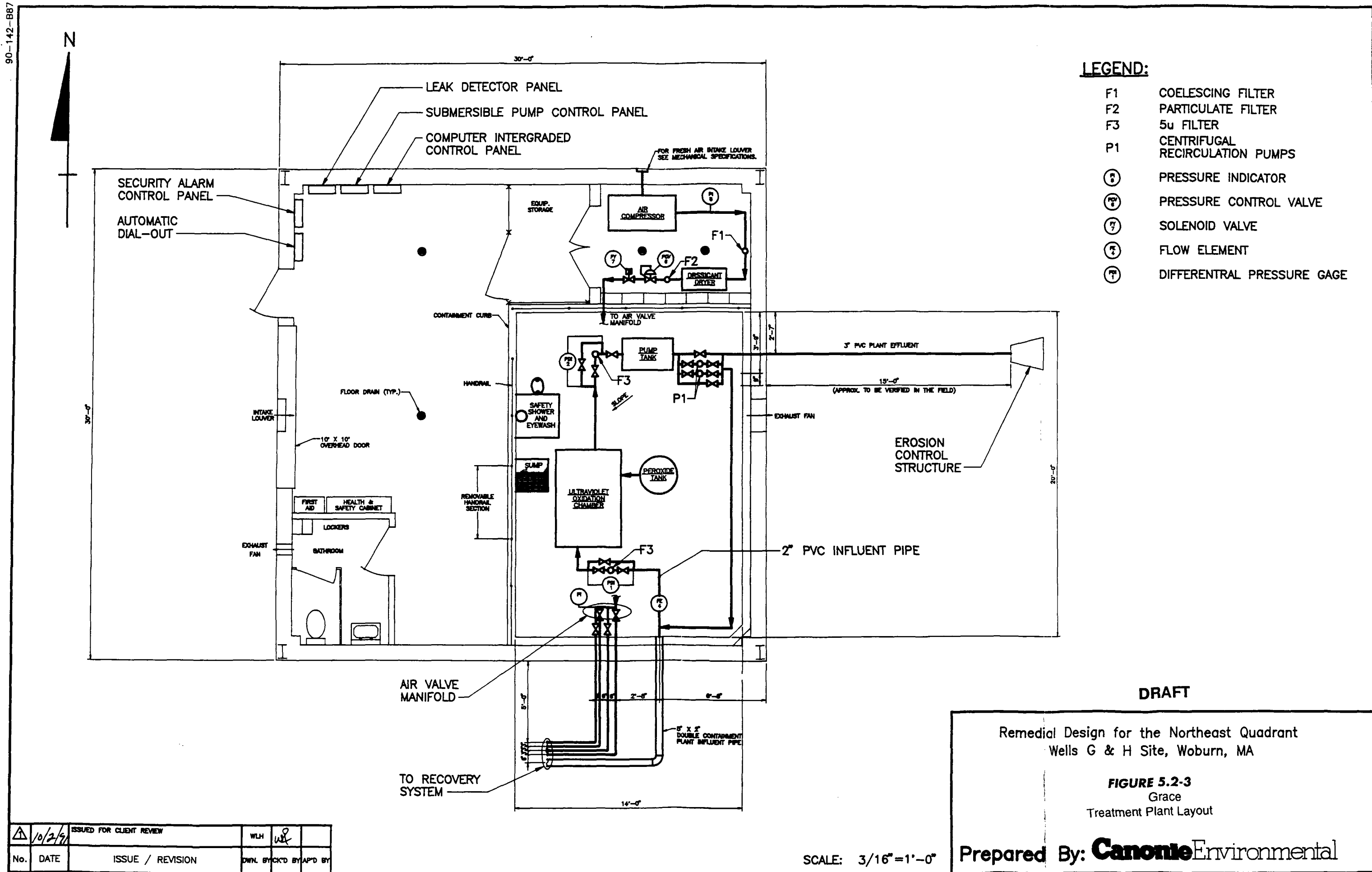
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Remedial Design for the Northeast Quadrant
Wells G & H Site, Woburn, MA

FIGURE 5.2-2
Grace
Final Design Process Flow Diagram

Prepared By: **Canonle** Environmental

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Bag Filters

Two bag filters have been included in the final design. One is in-line before the UV/oxidation system, and one immediately after. The bag filter before the UV/oxidation unit will collect suspended solids from the recovery system and prevent clogging and/or cloudiness from reducing the efficiency of the UV lamps. As discussed in Section 4.3.2.1, a significant amount of solids was collected during pilot plant startup. The second bag filter will collect metal oxides which precipitate in the UV/oxidation chambers. Although this amount is extremely small, as demonstrated in the pilot study, replacing filter bags is preferable to the discharge of suspended material into the creek. The filter bags will be 5 micron for maximum filtration without high headloss. It is anticipated that the filter bags will be changed once per month during treatment plant operation.


Pump Tank and Recirculation Pumps

A 400 gallon pump tank and two recirculation pumps are included in the final design for system startup, flexibility, and to allow for contingencies. During normal operation, treatment plant effluent will gravity drain to the creek.

Control/Data Acquisition System

A control system has been designed so that if any critical component of the treatment process fails, the entire process shuts down, preventing untreated ground water from being discharged. The control system will monitor the treatment process and automatically notify responsible personnel in the event of a failure. Included in the control system is a data acquisition system which will archive the flowing data:

1. Flow data from areas 1 through 4;
2. Total influent flow rate;
3. Peroxide flow rate;
4. UV/oxidation unit run time;

- 
5. Treatment plant failures and reason;
 6. Monitoring well water level data; and
 7. Discharge flow rate.

This information will be collected to provide treatment plant historical data for inclusion in quarterly reports to the EPA and to verify treatment plant performance.

Treatment plant final design construction drawings, technical specifications and work plans for the Grace property are contained in Volume III.

6.0 UNIFIRST SOIL AND DEWATERED BEDROCK FRACTURES REMEDIAL DESIGN

6.1 Introduction

The Record of Decision (ROD) and the Explanation of Significant Differences (April 25, 1991) (ESD) require soil remediation on the UniFirst property. The objective of this requirement is to prevent leaching of contaminants from the soil into the ground water to an extent that would cause contaminant concentrations in the ground water to exceed the ground-water clean-up action levels. Put another way, the objective is not to remove mass per se, but to remove soil contamination so as and to the extent necessary, to keep the soil from recontaminating the ground water above action levels.

The ESD specifies soil vapor extraction as the technology for remediating the soil. The ESD recognizes that the timing of the soil remedial action is closely tied to the progress of the ground-water remedial action because the source of the soil contamination on the UniFirst property is the contaminated ground water. This connection requires examination of the conditions on the UniFirst property and consideration of the efficiency of the proposed soil remedial action technology to satisfy the objectives of the soil remedial action.

In addition, the EPA has asked what might appropriately be done with regard to the bedrock fractures dewatered by the ground-water remedial action in hopes of effecting worthwhile mass removal from dewatered bedrock fractures that may contain immiscible phase DNAPL. This subject is not specifically addressed by the AOC, the ROD or the ESD.

As requested at a meeting with agency representatives on September 17, 1991, this section addresses these points in the context of an integrated conceptual model of the UniFirst property contamination. In this conceptual model, the local geology is reviewed, the presumed mode of introduction of the DNAPL to the subsurface is described, the distribution of contamination in the unsaturated, unconsolidated deposits is described and the configuration of the dewatered bedrock fractures is depicted. Based on this conceptual model, remedial hypotheses are put forth for managing the soil contamination and the dewatered bedrock fractures. Finally, a means of testing these remedial hypotheses is recommended.

6.2 Conceptual Model

6.2.1 Geology

As described in Section 2.0, the upland area of the Wells G & H Site (including the UniFirst property), is underlain by till. Immediately overlying the bedrock is a dense lodgement till consisting of a mixture of sand, silt, clay, gravel and boulders. In areas, an upper ablation till, which contains more sand and is less consolidated, occurs. At the east end of the UniFirst property, the thickness of unconsolidated deposits does not exceed 25 feet, and is typically less than 10 feet in the area of detected contamination. These deposits gradually thicken toward the west side of the UniFirst property.

The bedrock is mapped as Salem Gabbrodiorite, Dedham Granodiorite and undifferentiated metavolcanics. The surface of the bedrock is uneven, probably a result of preferential erosion of faulted zones. Regionally, a northeasterly trending buried bedrock valley traverses the central portion of the Wells G & H Site; the UniFirst property is located on the northeastern flank of this valley.

During the course of the investigations at the UniFirst property, monitoring wells have been installed into both the unconsolidated deposits and into the bedrock. Wells in the unconsolidated deposits and the shallow bedrock have slow hydraulic response characteristics, indicating that the permeability of both units is low. For example, these wells can be easily hand-bailed dry. Low permeabilities are common in tills, and none of the shallow bedrock wells intercept fractures that are capable of transmitting useful quantities of water.

Although faults have been mapped in the bedrock, the permeability of areas not directly faulted is low. The porosity of the bedrock has not been measured due to the unavailability of reliable tests for undertaking such measurements. Based upon the results of bedrock pumping tests, limited fracture porosity has been demonstrated to be available for ground-water flow. Where significant fracture porosity has been found (e.g. UC22), significant (e.g. 50 gpm for 30 days at 51 feet drawdown) quantities of water can be extracted from the rock. The bulk porosity of the rock (i.e. the aggregate fracture and non-fracture porosity), however, is low, probably less than one-tenth of one percent. As is commonly the case with bedrock, the fractures are not well connected to other fractures in the shallow bedrock.

Rock core collected from the Site and on the UniFirst property indicates that most of the fractures are high-angle (near vertical). Locating such fractures by vertical drilling is rarely controllable and is usually best left to luck.

Based upon data collected from monitoring wells drilled on the UniFirst property, the average annual water-table position is at an approximate average elevation of 60 feet above mean sea level. Thus, at the eastern end of the property, the water table is located within the bedrock. Due to the decline in the bedrock surface, saturated unconsolidated deposits are found at wells toward the west end of the property.

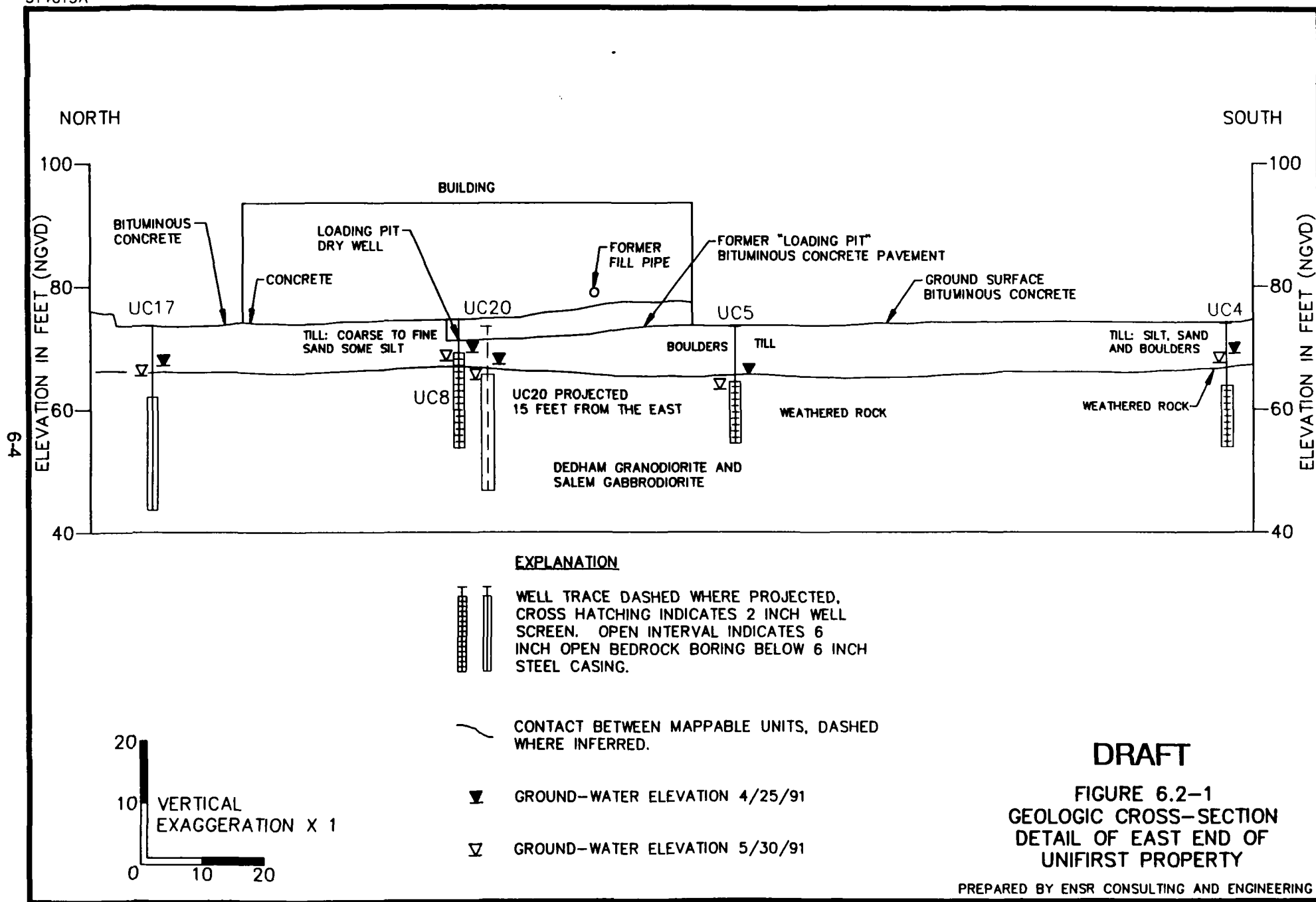
6.2.2 Disposal History and Source of Soil Contamination

Previous investigations at the UniFirst property have led to a hypothesis as to surmise the means of the introduction of DNAPL into the subsurface at the UniFirst property. Notwithstanding that all of this information has been previously presented in other documents, and here in Subsection 2.3.1.1, the remedial implications of this hypothesis are of sufficient importance to require repeating.

A 5,000-gallon storage tank, which was located inside of the east end of the UniFirst building, was used to store tetrachloroethene, primarily as a buffer against market fluctuations in price. Small quantities, less than fifty gallons, were pumped off for distribution to dry-cleaning plants at other locations. The fill neck for the tank was located outside of the building, near a former ramp loading dock. This area has since been built into an elevated loading dock and enclosed (Figure 6.2-1). To handle rainfall and runoff within the former loading ramp, it has been reported that there was a drain leading to a dry well. Although there is no direct evidence, it has been suggested that if delivery trucks drained their delivery hoses onto the loading ramp, this would have allowed product to flow through the drain and into the drywell.

Well UC8 was drilled through the reported location of this dry well some 20 feet into the bedrock. Based upon the thickness of unconsolidated deposits in the area of the loading dock as encountered in well UC8, and assuming a typical drywell that is approximately three feet deep, the distance between the bottom of the drywell and the bedrock would be small, approximately two feet. For this reason, there would be virtually no unconsolidated deposits to be contaminated by infiltrating (migrating) tetrachloroethene which may have been released in the former loading dock area. Moreover, no DNAPL or even substantially elevated $\text{HN}\mu$ readings were encountered during drilling UC8. By the next day, however, some 2 ½ liters of DNAPL had drained in well UC8, apparently from the shallow bedrock, and were discovered in the well.

Despite extensive test pitting, excavation and borings, no DNAPL has ever been detected in the unconsolidated, indicating that tetrachloroethene has not been introduced to the subsurface by surface release through the unsaturated, unconsolidated deposits. Rather, the cause of the ground-water contamination appears to be DNAPL introduced directly into and occupying fractures within the bedrock and diffusion of this DNAPL into the ground water. Further vapor



phase diffusion from the ground water to overlying unconsolidated deposits appears to be the cause of the soil contamination. This was demonstrated by installation of borings into a former test pit and measuring recontamination, installing vapor "wells" at the top of rock, and modeling of the results. ENSR's letter report (February 28, 1989 and March 18, 1989, Appendix Q) described this demonstration.

For this reason, soil remediation at the UniFirst property will only remove contamination that has volatilized from the water table and adsorbed to soil particles and occurs as constituent of pore gas. Since the volatilization will continue until the ground water is clean, until recent advances in DNAPL science, sequencing the soil vapor extraction to occur upon achievement of some steady-state ground-water concentration appeared to be the only effective solution.

One-dimensional numerical modeling of the steady-state concentrations of tetrachloroethene on soil particles, in soil vapor, and in soil water in the unsaturated zone thus was undertaken to determine an appropriate value for the acceptable, steady-state ground-water concentration that would not cause continual recontamination of the overlying, unsaturated, unconsolidated deposits at concentrations above action levels. This modeling indicated that the appropriate steady-state ground water concentration would approximate 85 micrograms per liter (see Applied Groundwater Research's reports of March 15, 1989 and July 30, 1990 in Appendix Q). The results of this modeling have been provided in earlier submissions and are again provided in Appendix Q.

6.2.3 Extent of DNAPL

DNAPL has been detected only in well UC8. Subsequent to the discovery of DNAPL in well UC8, a series of shallow bedrock wells were installed around the perimeter of the building on the UniFirst property (wells UC 16, 17, 18, 19 and 20). None of these shallow bedrock wells encountered DNAPL. Several of these wells and earlier wells including UC 5, 7, 16, 17 and 20 contained concentrations of dissolved tetrachloroethene that are indicative of nearby DNAPL. The configuration of these wells, which contain high dissolved concentrations of tetrachloroethene, indicates that the extent of DNAPL is really limited within the perimeter described by these wells. The depth to which the DNAPL has penetrated into bedrock fractures is not known. The high aqueous concentrations noted at the shallow bedrock wells and that were produced in well UC22 during pumping, indicate that the DNAPL in the vicinity of well UC8 is capable of dissolution and movement through local pathways defined by joints and faults in the bedrock.

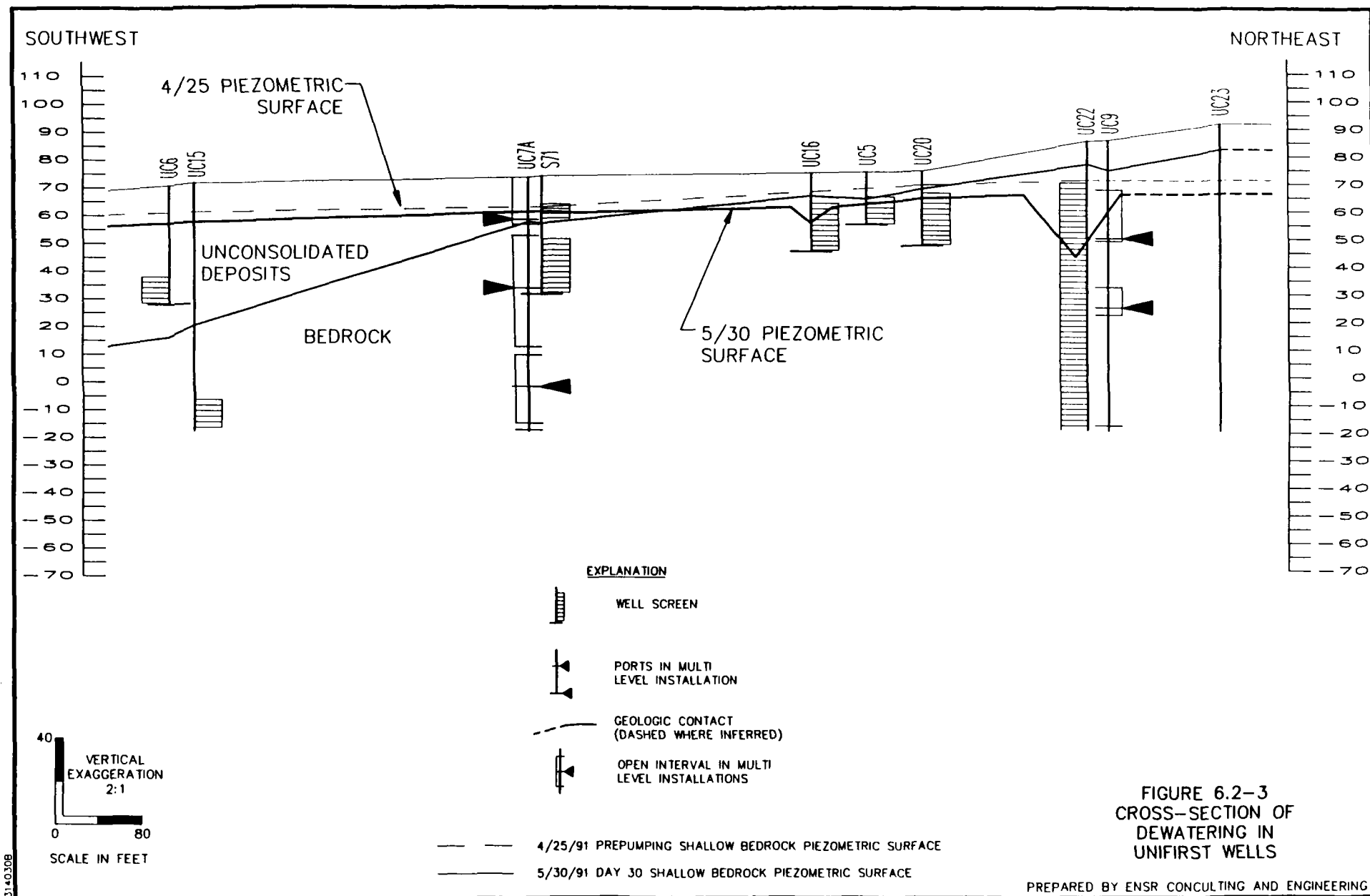
6.2.4 Dewatered Bedrock Fractures

The pumping of UC22 during the 30-day test caused water-level declines in some monitoring wells on the east end of the UniFirst property. These declines ranged up to approximately 12 feet, causing sets of interconnected bedrock joints and fractures to become dewatered. The pattern of dewatering is difficult to interpret because dewatering in bedrock is preponderantly confined to narrow, roughly planar joints and fractures. Figure 6.2-2 provides an interpretation of a reasonable pattern of dewatering in the bedrock joints and fractures based on the measured decline in water level in the wells. The pattern is generally linear and irregular, which is to be anticipated, because it follows the joint patterns. Figure 6.2-3 is a cross section that illustrates the local dewatering of bedrock fractures intersected by some wells on the UniFirst property. These two figures demonstrate the small volume and irregular pattern of dewatering in the bedrock fractures.

The horizontal and vertical extent of this joint and fracture dewatering during continuous pumping of UC22 at 50 gallons per minute will be better mapped during long-term monitoring of the ground-water remedial action. Substantial time may be required to allow for dewatering of the slowly responding bedrock fractures. In addition, the transient effects of precipitation and seasonal changes have not been measured. However, based on the extent of measured change in the water level in the bedrock fractures that developed during the pilot test, questions have been raised with regard to the potential for removal of residual DNAPL that may occupy these dewatered bedrock fractures.

Before evaluating methods for removing any residual DNAPL which may become "trapped" in the bedrock fractures, the nature and relationship of the water, rock, and vapor in the bedrock system must be understood. These three components form a very complex, three-phase system that is not only difficult to investigate, but frequently defies understanding. The following explanation is provided based on recent advances in DNAPL science.

When the DNAPL entered the bedrock system, it would have moved along the available bedrock fractures, probably in a primarily downward direction, with lateral migration being the result of the actual orientation of the fractures. The lack of direct detections of DNAPL in wells UC5, 16, 17 and 20 and the near vertical orientation of fractures observed in the rock cores indicate that lateral migration in the shallow rock was very limited. The downward migration would have occurred quickly, even when the DNAPL reached the saturated zone, due to the high density and low viscosity of tetrachloroethene and the orientation of the fractures. As the DNAPL moved along fractures, some portion would have flowed into "dead-end" fractures—those with apertures too small to allow further movement or those that terminated abruptly. Some such fractures appear to have contained a relatively small amount of DNAPL until "drained" by UC8.



While the frequency of occurrence and the dimensions of individual fractures in the bedrock at the UniFirst property are not known, those that would be considered "dead-end" are probably numerous. However numerous these small fractures may be, the total volume of these fractures is nevertheless very small. DNAPL migrating in a primarily downward direction would have passed by many of these small fractures and probably entered some of them, essentially becoming "trapped." After entering such a fracture, the DNAPL probably did not undergo any further movement (except and until intersected by UC8).

Removal of the DNAPL from this type of fracture requires that the DNAPL dissolve into the surrounding water. Since the water probably does not move readily from the fracture, movement of the contaminated water into larger fractures would occur primarily by diffusion.

Any DNAPL that may remain in the dewatered shallow bedrock would be found only in such fractures. As continuous pumping causes water-level declines at the pumping well and in nearby wells, shallow bedrock fractures that were previously saturated will become tension-saturated. This terminology is very important—"dewatered" strongly suggests that only air (and maybe DNAPL) will occupy the fractures after the water is removed, but "tension-saturated" more accurately reflects the distribution of water and air (and maybe DNAPL) found in the fractures.

That is, although it cannot be observed directly, a complex relationship exists between the three phases of a DNAPL-contaminated, tension-saturated fracture. The natural tendency is to envision DNAPL droplets and water droplets clinging to the fracture walls, surrounded by a gas that will be a mixture of air, water vapor and DNAPL vapor. Each component is typically viewed separately, possibly located adjacent to another component. Such compartmental visualization does not accurately reflect the complexity of the relationship among the components. The DNAPL droplets, blebs or beads may be surrounded by a water layer, possibly only microscopically thin, but a layer that prevents volatilization directly from the DNAPL to the fracture vapor. The droplets surrounded by water layers may be joined together to form short chains of water-encased DNAPL, or they may be isolated from other droplets. Whichever is the case, the removal of DNAPL under these circumstances is difficult because it relies first and foremost upon dissolution of the DNAPL into the water layer before volatilization into the fracture vapor. This three-phase system is not any different than that which occurs in tension-saturated (and unsaturated), unconsolidated deposits; however, the level of homogeneity among the systems and their ability to transmit fluids are vastly different.

As dewatering occurs, vapor (primarily air) will enter the fractures to replace the water that has drained. The air will move through fractures in the bedrock that have the least restriction—the

largest tension-saturated fractures will fill with air first. Eventually, this air will move into the smaller, and possibly even the dead-end fractures.

6.3 Remedial Hypotheses

This section reviews the limited remedial techniques that may be appropriate for remediating the contaminated unconsolidated deposits and hypothesized residual DNAPL/dissolved/vapor phases in the dewatered bedrock fractures in light of the foregoing conceptualization.

6.3.1 Soil Remedial Hypotheses

6.3.1.1 Soil Vapor Extraction

The source of soil contamination and the nature of the unconsolidated deposits render soil vapor extraction inefficient, and, if at all appropriate, limited to a strict sequencing of implementation. Unconsolidated deposits underlying the UniFirst property have been demonstrated to be of very low permeability. Unconsolidated deposits of this nature cause air-flux to be inefficient and typically characterized by movement in preferential pathways effected by inhomogeneities in the naturally-occurring deposits and, more commonly, high permeability zones created by structures such as drain pipes, fractures in pavement and back-fill around foundations.

Soil-vapor extraction systems have been designed for and are only proven effective in the presence of immiscible phase liquids that are contained in a permeable vadose zone. As explained above, no immiscible phase fluid has been detected or is expected to be located in the unconsolidated unsaturated deposits on the UniFirst property. Implementation of soil-vapor extraction would rely on an extremely tightly-spaced suction-well placement, that would by no means guarantee removal of vapors at any useful distance from the suction wells.

Discussions with vendors (Vapex and Terra Vac) substantiate the above described observations. These highly-experienced vendors anticipate a very short "puff" of elevated vapor concentrations that would be followed by extremely low-level concentrations that would be sustained and governed by the rate of diffusion of compounds from the dissolved state within bedrock fractures across the limited cross-sectional area defined by the intersection of the bedrock joints and fractures with the overlying unsaturated, unconsolidated deposits.

The foregoing characteristics of the UniFirst property soil and soil vapor extraction technology indicate that this technology may not be the first choice for effecting soil remediation at the UniFirst property, quite apart from the issue of sequencing. That is, the point of soil remediation at the UniFirst property is to mitigate the contamination of percolating water. Percolating water

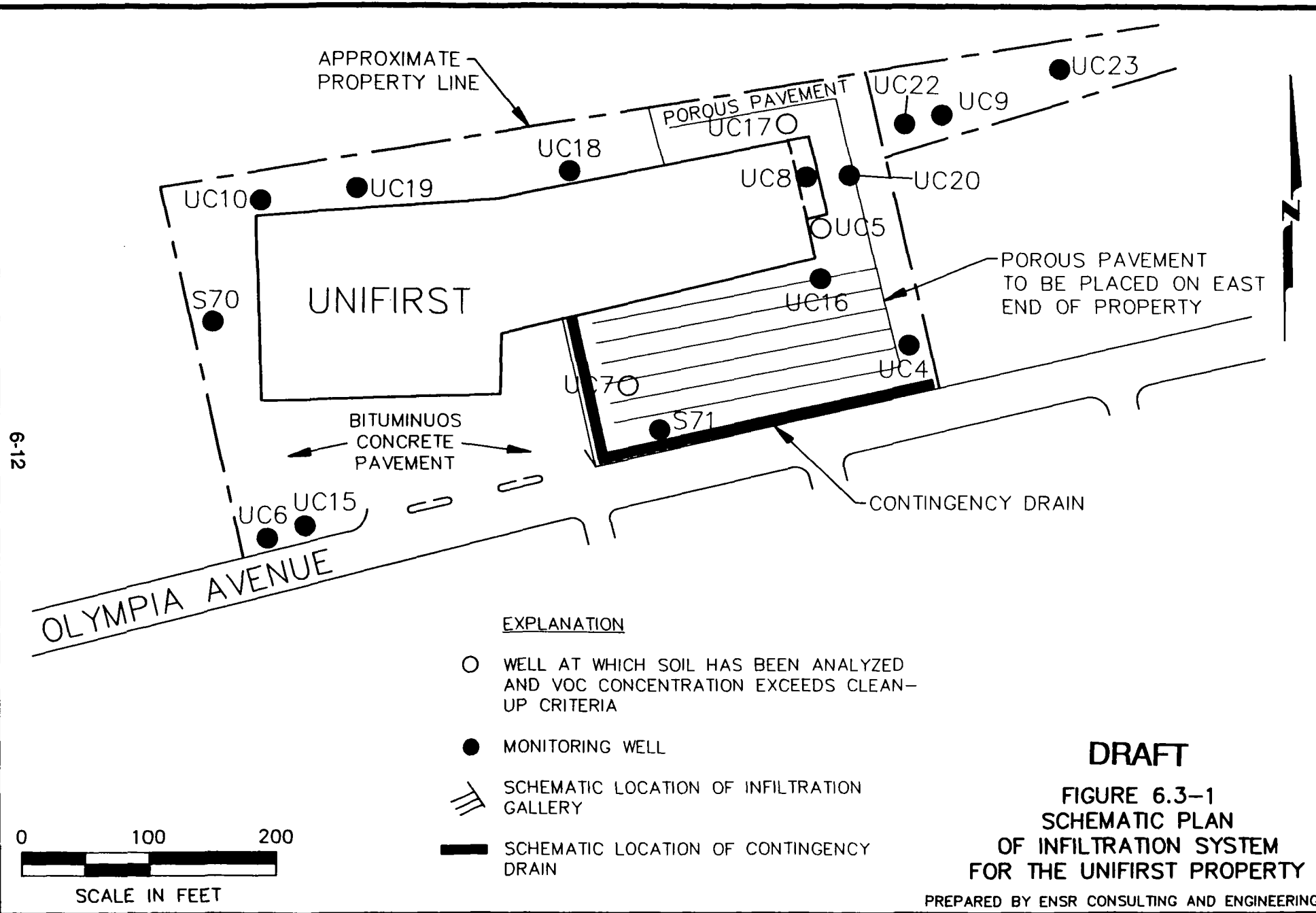
will preferentially seek and be contaminated by the smaller soil pores, the very ones least likely to be accessed and remediated by soil vapor extraction. Therefore, a more effective, and aggressive soil remediation hypothesis is proposed: immediate water infiltration followed by soil vapor extraction in any "hot spots" that remain when the 85 µg/L equilibrium ground-water concentration is approached, to the extent they may cause ground-water concentrations to exceed water action levels and are shown to be able to be more effectively addressed by soil vapor extraction than by continued infiltration.

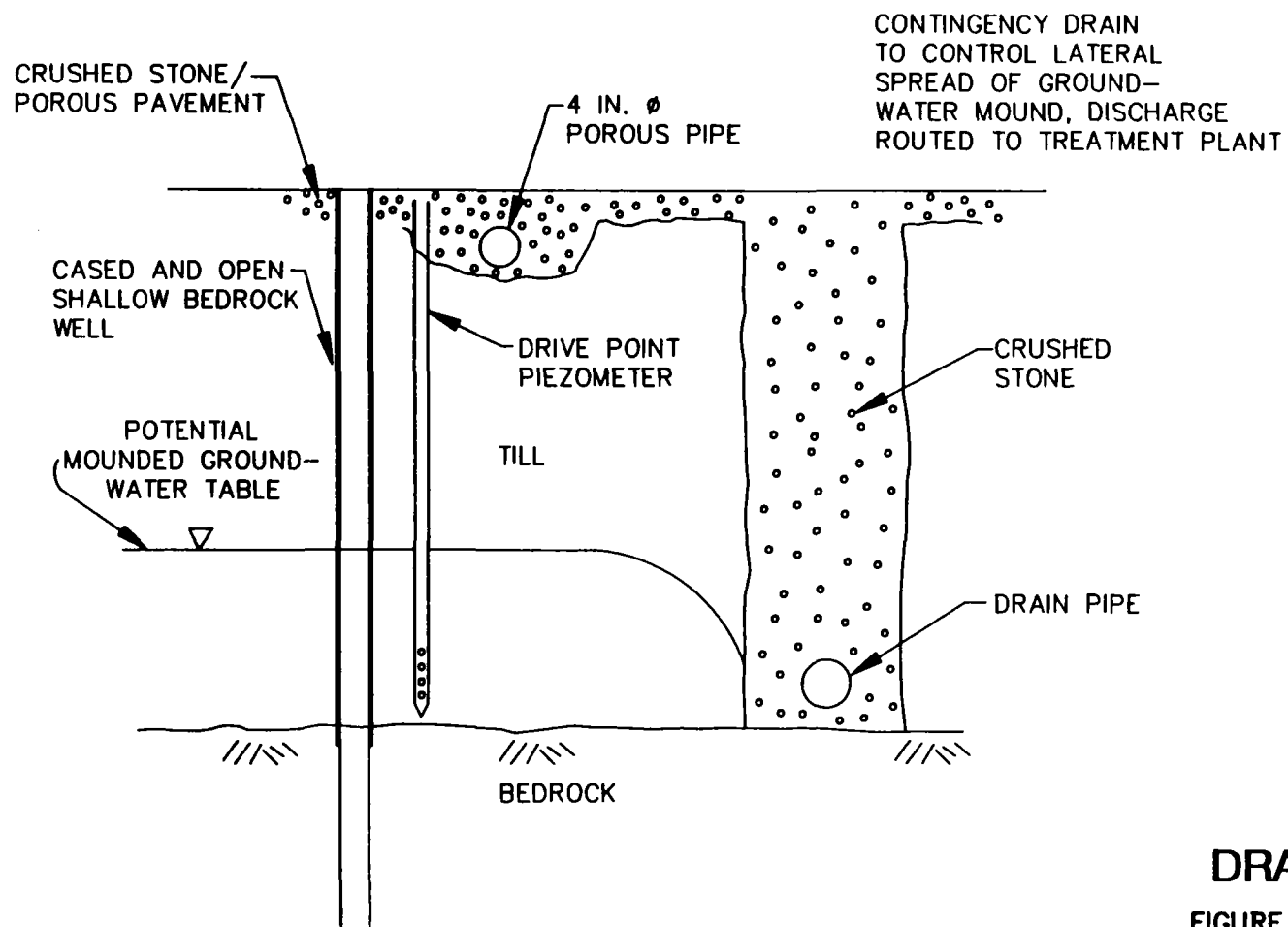
6.3.1.2 Infiltration

This section describes a more immediate, effective alternative means of effecting remediation of soil-pore gas that may impact percolating ground water. An infiltration remedial system would consist of pumping treated ground water from the UniFirst ground-water treatment system through a system of porous pipe galleries installed within porous pavement around the area in which soil contamination over the action level has been encountered (Figures 6.3-1 and 6.3-2). As explained below, it would simulate the natural percolation process and preferentially remove contamination from the soil pores that would contact and contaminate naturally infiltrating water. Also as explained below, it could be implemented as soon as the ground-water remedial action commenced, rather than awaiting the approach of the 85 µg/L equilibrium concentration.

Use of water as the remediating medium would be more effective for several reasons. First, the contamination of concern is not present in the unconsolidated unsaturated deposits as an immiscible phase. It is believed to be present as a vapor within soil-pores and absorbed in combination with water to soil particles. In such a state, it is anticipated that water would be more efficient in dissolving the contamination and in mobilizing it to a point of collection than vapor extraction would be in vaporizing it and extracting it, due to the complex three-phase physics described above and the relatively low vapor pressure of tetrachloroethene. Second, infiltrating water preferentially follows narrower pathways of migration over larger pathways of migration; therefore, effecting a greater coverage of the remedial-fluid flux. Finally, the infiltration system provides an integrated system with dewatered bedrock fractures. That is, infiltrated water that courses through the unconsolidated deposits would be available to pass through the dewatered fractures, because the dewatered fractures are below the area of measured soil contamination.

The proposed infiltration system would consist of a system of porous concrete pipes installed in crushed stone that would replace the bituminous pavement on the eastern portion of the UniFirst property, as shown on Figure 6.3-1. Also as shown in Figure 6.3-1, a French drain would be installed on the UniFirst property downgradient of the infiltration system to mitigate the potential for mounding to cause off-site migration. The water for the system would come from



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**FIGURE 6.3-2
SCHEMATIC SECTION OF
INFILTRATION SYSTEM FOR
THE UNIFIRST PROPERTY**

NOT TO SCALE

the UniFirst treatment system, be collected by UC22 and the French drain, and be returned to the treatment system for treatment. The system and the pump in UC22 are adequately sized and designed to handle this water while maintaining the capture zone. The infiltration would be interrupted during freezing weather.

The success of the infiltration remedial action could be directly monitored through extraction and analysis of ground water samples withdrawn from shallow drive-point piezometers installed to the top of rock and from the French drain. A monitoring program could consist of analyzing samples of the shallow ground water prior to installation of the system. These data would provide a base-line against which the performance of the infiltration system could be monitored. Subsequent sampling and analysis of ground water after the start-up of the infiltration system would provide a means of gauging changes in concentrations noted in the shallow ground water. It is anticipated that as infiltration proceeds, contaminants in the unconsolidated deposits would be flushed downward into the ground water and diffusion of additional contaminants from the source and the contaminated ground water would be prevented from diffusing upward. Therefore, it is anticipated that decreasing concentrations in the shallow ground water would be measured and would be indicative of clean-up of the overlying soil. Thus would be provided a direct measure of the soil's capacity to cause concentrations in the ground water that are greater than the ground-water clean-up criteria. These direct measurements would supplant the mathematical leaching models and reliance upon assumed field conditions.

If the percolating water were still above the ground-water action levels as the ground water approached the 85 µg/L equilibrium number, the infiltration would be suspended and a soil vapor extraction study would be commenced. The persistence of soil contamination "hot spots" would be determined, and those identified would be subjected to a soil vapor extraction pilot test to determine whether it would be more effective to substitute soil vapor extraction for continued infiltration.

6.3.2 Dewatered Bedrock Fracture Remedial Hypotheses

6.3.2.1 Vapor Extraction

Vapor extraction is infeasible for the bedrock fractures that would be "dewatered" during long-term pumping of UC22. Continuing investigations on the UniFirst property have clearly indicated that the shallow bedrock is too tight to provide for worthwhile soil-vapor extraction. Soil-vapor extraction is clearly limited to areas where immiscible phase fluid exists. Immiscible phase fluid has been detected only in well UC8 at the UniFirst property. Further, vapor extraction technologies both are unlikely to contact and remove any DNAPL that may persist in the shallow bedrock due to the three-phase physics and dead-end fracture problems discussed above, and

may remobilize any such DNAPL by changing the pressure gradients within the fracture system. This remobilization risk would be dramatically increased by any attempts to install new wells in the rock or to increase its fracturing by blasting or hydrofracture technique.

6.3.2.2 Infiltration

Infiltration of water through the dewatered bedrock fractures would be an additional benefit derived from infiltration through the unconsolidated and unsaturated deposits on the property. The advantage of this technology is that water, as the remedial medium, would preferentially seek the smaller fractures and flush through them before flowing through the larger fractures. In this manner greater flux through available fractures would be achieved than by soil-vapor extraction, which preferentially seeks the larger apertures and more permeable zones.

Additional efficiency is gained because the infiltration process would carry the contaminants of concern from the dewatered bedrock fractures into the zone of capture of well UC22, whence the contaminants would be extracted and destroyed in the treatment plant. Infiltration as a remedial hypothesis provides an integrated, simple and reliable system that will remediate the contaminated soil and provide for a flux through the dewatered bedrock fractures where DNAPL and/or dissolved concentrations of volatile organic compounds may exist.

6.3.2.3 Rewatering/Drawdown Cone Fluctuation

Rewatering of the dewatered bedrock fractures could be effected in two ways. First, it is anticipated that clean-up of the dissolved concentrations in the bedrock fractures in the distal portions of the contaminated ground water, would clean-up relatively rapidly since the bedrock fractures have virtually no absorptive capacity, and the storativity of the bedrock fractures is enormously lower than that of unconsolidated deposits. Therefore, as clean-up is detected in the distal portions of the contaminated ground water, the discharge of well UC22 would be reduced to effect a reduction in the extent of the capture zone. This reduction in the areal extent of the capture zone would also be manifested in a rise in the ground water elevation in the dewatered bedrock fractures. Therefore, lower portions of the formerly dewatered bedrock fractures would once again become saturated and swept by ground water that would be collected in UC22 and treated in the UniFirst treatment plant.

Secondly, rewatering could be effected by fluctuating the pumping rate of UC22. Fluctuation of the pumping rate would result in the same rewatering of bedrock fractures as described above. Such purposeful fluctuation of the discharge rate would have to be tightly coupled with an analysis of the rate of decay of the zone of capture so as to not risk release of compounds that are normally held within and removed from the capture zone.

The advantages of this remedial hypothesis are that it is simple and integrated with long-term management of off-property migration. Secondly, continued dependence upon the ground-water-extraction and -treatment system as the overall remedial technology provides for on-property destruction of the compounds.

6.4 Testing the Remedial Hypotheses

The foregoing conceptual model of the UniFirst property and the discussion of the remedial hypotheses indicate that the following sequencing of remedial action and testing of the hypotheses is most appropriate to effect remediation of the unconsolidated deposits and appropriate management of dewatered bedrock fractures. The proposed test of remedial hypotheses includes the following:

1. Implement the ground-water remedial action as soon as practical. The sooner UC22 starts pumping, the sooner the long-term configuration of the ground-water table that results from pumping conditions will be known. The long-term configuration of the ground-water table will be important to the design of the management system for the dewatered bedrock fractures.
2. Remove the remaining pavement from the east half of the parking area around the building and below which contamination of the unconsolidated deposits has been measured.
3. Install shallow piezometers to measure baseline conditions in the shallow ground water.
4. Install a water-infiltration system. This would consist of a leaching-field-type array of porous concrete pipes through which a portion of the effluent from the ground-water treatment plant would be pumped. If necessary, a drain, as illustrated in figures 6-4 and 6-5, would be installed to prevent off-property migration of infiltrated ground water that may mound (some mounding may be desirable) below the infiltration system. Water collected in the drain would be cycled through the ground-water treatment plant.
5. Operate and monitor UC22, the infiltration system and the treatment plant. The infiltration system would be operated seasonally as frost permits.
6. Operate the infiltration system until the concentration in the bedrock ground water achieved 85 micrograms per liter or less tetrachloroethene in four successive quarterly sampling rounds. At this point, the bedrock ground water could no longer recontaminate the overlying unsaturated, unconsolidated deposits.

7. Upon achieving 85 micrograms per liter or less in the bedrock ground water, the infiltration system would be shut down. If the shallowest ground-water-monitoring points indicate continued leaching of compounds from the "normally" unsaturated unconsolidated deposits, these residual areas of contamination would be investigated for application of soil-vapor extraction. This residual "hot spot" investigation would be designed based on then available data.
8. Soil-vapor extraction would be performed at any residual "hot spots" that are determined to be amenable to the technique.
9. If soil-vapor extraction is not amenable to final treatment of residual "hot spots" the infiltration system would continue to be operated.

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EXPLANATION

• S72 WELL SHOWING

WELLS G&H SITE

STUDY AREA

NORTHEAST QUADRANT

GRACE AND UNIFIRST
SOURCE AREA PROPERTIES



SCALE IN FEET
0 50 100 200 400

Note:
Base Map Prepared By Col-East
Inc. At A Scale Of 1 Inch = 100 Feet
From April 1980 Aerial Photographs

REMEDIAL DESIGN FOR THE
NORTHEAST QUADRANT
WELLS G & H SITE WOBURN, MASS.
PLATE 1
WELLS G&H SITE MAP

Prepared by GeoTrans, Inc.

No.	Date	Revisions
1	9/12/91	Add wells
2	10/15/91	Add boundaries

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